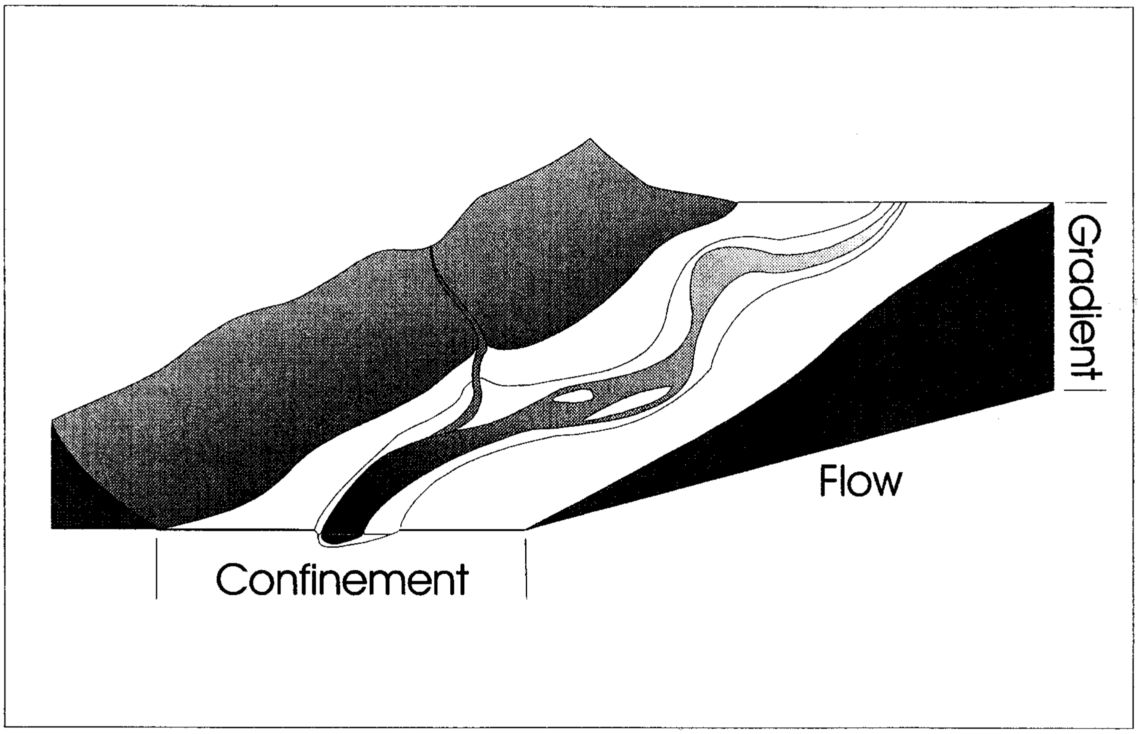
TFW-AM9-98-001

TFW Monitoring Program

METHOD MANUAL

for

STREAM SEGMENT IDENTIFICATION



by:

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May 1998

Timber Fish & Wildlife

Pleus, A.E. and D. Schuett-Hames. 1998. TFW Monitoring Program methods manual for stream segment identification. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-98-001. DNR #103. May.

Abstract

This manual provides a standard method for systematically identifying stream segments on the basis of channel morphology and floodplain characteristics. These segments are used as the basic framework for designing monitoring study plans and conducting monitoring surveys for the TFW Monitoring Program, Watershed Analysis, and the Salmon and Steelhead Habitat Inventory and Assessment (SSHIAP) process. The primary stream segment characteristics are: 1) stream order/relative basin drainage area; 2) channel gradient; and 3) channel confinement. The manual provides basic segmenting techniques with clear, step-by-step explanations and examples that illustrate the application of the methods in various stream situations. It is divided into office methods, field verification, post-field documentation, and data management sections. A sub-segmenting process has been included to provide flexibility to address the specific needs of individual studies and as a linkage to other stream classification systems. An extensive appendix section includes a materials and equipment source list, copy masters of documentation forms and worksheets, examples of completed forms and worksheets, a glossary, a data report example, and segmenting task checklists.

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Copying of the Method Manual

All TFW Monitoring Program method manuals are public documents. No permission is required to copy any part. The only requirement is that they be properly cited. Copies of the methods manuals are available from the TFW Monitoring Program at the Northwest Indian Fisheries Commission or from the Washington Dept. of Natural Resources.

By the end of 1998, copies will also be available through our internet site at:

http://www.nwifc.wa.gov

Acknowledgements

The development of this document was funded by the Timber-Fish-Wildlife (TFW) Cooperative Monitoring, Evaluation, and Research (CMER) committee through a grant from the State of Washington. Northwest Indian Fisheries Commission (NWIFC) staff members including Tony Meyer, Sheila McCloud, Doug Williams, Mike Messenger, Craig Carns, and Lois Allen have provided valuable proofing, layout, and production assistance. TFW Monitoring Program (TFW-MP) staff members Amy Morgan and Devin Smith contributed a great many hours collecting information, reviewing and editing drafts, and helping with production. Salmon and Steelhead Habitat and Inventory Assessment Project (SSHIAP) staff members including Randy McIntosh, Osa Odum, and Jennifer Cutler provided important assistance in the development and testing of methods. Thanks to the TFW Monitoring Advisory Group members including Randy McIntosh and Jeff Light (Co-chairs) for their support and guidance.

It is also important to recognize those people involved in the development of the Watershed Analysis Channel Assessment Module who originally developed the gradient/confinement system of stream classification. Special thanks to Tim Beechie of the Skagit System Cooperative for contributing to the original development of the TFW method.

Contents

Stream Segment Identification Method

1. Introduction

The Timber-Fish-Wildlife Monitoring Program (TFW-MP) provides standard methods for stream monitoring that reliably detect changes and trends in stream channel morphology and characteristics over time. The Stream Segment Identification method is an important tool for designing stream monitoring studies and interpreting results. This method has been approved by TFW's Cooperative Monitoring, Evaluation and Research Committee (CMER) and is accepted as a standard method for stream monitoring on forest lands in Washington state by tribal governments, state natural resource agencies, timber industries, environmental organizations, and others.

Stream Segment Identification Method - 1998 version, incorporates revisions designed to help cooperators segment streams with greater ease, accuracy and consistency. These changes are part of the program's adaptive management process to improve the science of monitoring and respond to cooperator needs. It provides a clear, step-by-step explanation of the segmenting procedures with examples that illustrate the application of the methods in various circumstances.

The introduction section outlines the purpose of the Stream Segment Identification method and describes its background, monitoring approach, and information on cooperator services. Section 2 describes the procedure for identifying stream segments in the office with topographic maps and supplemental information. Section 3 describes field verification procedures to check the accuracy of segment identification and boundary placement. Section 4 describes the procedure for documentation of segment identification information on Form 1. Data management is discussed in section 5 and references are provided in section 6. An extensive appendixes section contains a glossary, information and equipment sources, copy masters of worksheets and field forms, examples of completed worksheets and field forms, a database report example, and a segmenting task checklist.

1.1 Purpose

The purpose of the Stream Segment Identification Method is to provide:

1. A standard procedure for systematically identifying stream segments for conducting monitoring surveys on the basis of channel and floodplain characteristics, including:
    - a) relative basin drainage area
    - b) channel gradient
    - c) channel confinement.

2. A tool for study design and interpretation of monitoring data that guides:
    - a) selection of monitoring segments based on predicted channel response to changes in inputs of sediment, water, and wood
    - b) comparisons between similar segments and reference sites.

3. A structure for attaching, sorting, and tracking monitoring information that provides:
    - a) positive identification of segment location within a stream
    - b) a documentation system for tracking data over time
    - c) a flexible sub-segment option for attaching past or non-TFW data.

4. A system for organizing information on stream channels and salmonid habitat that can be readily interpreted and accepted by a broad range of resource managers, processes, and databases including:
    - a) the Watershed Analysis process
    - b) the TFW Monitoring Program database
    - c) the Salmon and Steelhead Inventory and Assessment Program database.

1.2 Background

The TFW monitoring program uses the steam channel classification system described in the Washington State Watershed Analysis Stream Channel Assessment Module (WFPB, 1995a) as a framework for collecting and interpreting monitoring information from stream channels. This system divides watershed stream networks into a series of similar stream segments defined by hydrologic and geomorphic changes including tributary junctions, channel gradient, and valley confinement. Gradient and confinement are the key geomorphological parameters of this classification system because of the control they impose upon channel geomorphology and their influence on the potential response of the channel to input changes of water, sediment, and wood. Stream segments are classified as one of 18 possible segment types, depending on their combination of gradient and confinement. The 18 types are derived from the combination of six channel gradient categories and three valley confinement categories (Table 1).

Table 1. Watershed Analysis and TFW Monitoring Program channel gradient and valley confinement categories.

Channel Gradient Categories	Valley Confinement Categories
< 1 %	Unconfined
1-2 %	
2-4 %	Moderately Confined
4-8 %	
8-20 %	Confined
> 20 %	

This stream segment classification system helps with the design of TFW stream channel monitoring projects and interpretation of results. Dividing stream networks into stream segments provides monitoring units of manageable size. Dividing stream networks into similar stream segments reduces within-reach variability, allowing more accurate and meaningful characterization of channel conditions and increasing the capability of detecting trends.

The Watershed Analysis stream channel classification system is useful for designing monitoring studies because it provides a means of predicting the response of stream segments to input changes. Refer to Appendix I to see copies of the WSA Channel Response and habitat quality rating matrices. This information can be used to select segments expected to respond to human activities, and to determine appropriate monitoring parameters and survey methods.

Finally, the stream classification system provides a template that guides comparison of information from similar stream segments within and between watersheds, and extrapolation of results to similar segments.

1.3 Monitoring Approach

Monitoring requires the highest level of consistency in both methods and in crew application of those methods. The TFW Stream Segment Identification method provides a rigorous approach to ensure that stream segments delineated for monitoring surveys by various cooperators are consistent and comparable. To accomplish this, the method provides both an objective template for identifying patterns in channel morphology and a systematic process for organizing them into a manageable monitoring framework.

The products produced by this method include:

- A stream system or watershed map delineating stream segments based on stream/drainage basin size, gradient, and confinement
- Segment boundary location information
- Segment characteristic information based on maps and field verification.

The segment method uses a systematic process to prioritize individual watershed characteristics for determining segment boundaries. This process starts with map work in the office and concludes with field verification of segment boundaries and characteristics. The office stream segment identification method is conducted using topographic maps and supplemental information. This provides the first cut for identifying candidate monitoring segments and can significantly reduce field verification.

Field verification is required before conducting monitoring surveys to check the accuracy of segment descriptions and boundaries identified during the office procedure.

Guidelines for sub-segmenting are included, providing flexibility for cooperators to meet individual monitoring needs. The sub-segment system provides a structure for attaching information from other surveys to TFW-MP segments. It also provides documentation of survey boundaries for smaller units of analysis where local conditions require them.

The TFW Monitoring Program recommends that all pre-segmented boundaries be thoroughly checked using the methods presented in this manual. Segment information that has not been field verified is considered inaccurate for monitoring purposes. These segments may have been modified to meet individual project needs and therefore may not be suitable for other purposes. Refer to Appendix A for pre-segmented stream resources and contact information.

1.4 Cooperator Services

The TFW Monitoring Program provides a comprehensive suite of services to support TFW cooperators. Services include study design assistance, pre-season training through annual workshops and on-site visits, pre-season quality assurance reviews, data entry systems, summary reports of monitoring data, and database/data archiving services. These services are offered free of charge. To find out more about these services and the TFW Monitoring Program, contact us or visit our link on the NWIFC homepage. The address is:

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2. Office Stream Segment Identification Method

This section provides procedures and examples for identifying stream segments for TFW-MP purposes and describes how to document additional information on segment characteristics. Information from topographic maps and supplemental information is used to stratify the stream into unique segments based on relative basin drainage area (stream order) and channel function, channel gradient, and channel confinement. The objective is to identify all candidate segments along the entire stream length. This provides the first cut or "big picture" view of a watershed in relation to potential input sources, causal mechanisms and response characteristics that may not be evident by partial stream segmenting. After candidate segments have been identified in the office, final segments are selected based on field verification.

The procedure involves creating independent layers with segment breaks based on stream order and non-fluvial features, channel gradient, and channel confinement marked on them. Separating these layers onto individual map worksheets provides a clear and more objective framework for identifying final segment breaks and resolving complex situations. This framework is important to prevent biases in lumping and splitting. As skill level increases with this method, map worksheets can be combined. In the last part, the layers are combined and lumping/splitting rules provided for resolving complex segment boundary situations.

Good documentation of this process provides clear paths of decision-making and produces valuable information about the entire stream system that may be important for analysis or guiding future surveys. A segmenting task checklist is provided as a quick reference guide and for documentation of the procedure used to arrive at segment break locations (Appendix G). Familiarity with interpretation of United States Geological Survey (USGS) topographic maps is a valuable skill and can significantly improve segmenting identification and documentation accuracy. Refer to Appendix A for map interpretation resources.

The segmenting procedure will be explained using the example of one stream (from mouth to headwaters) within a watershed. A stream for TFW-MP purposes is identified as having one unique Water Resource Inventory Area (W.R.I.A.) reference number. This procedure can be applied on a watershed level by systematically following the same methods stream by stream.

If a stream has already been segmented using only topographic map information, a review of the segment boundaries is recommended. Use supplemental information to cross-check locations and make necessary adjustments. If a stream has already been segmented using both topographic and supplemental information, skip to the "Field Segment Verification" section. The office stream segment identification method section includes information on preparation, procedures, and optional sub-segment identification.

2.1 Office Preparation

Step 1: Gather and organize all core and supplemental materials/equipment.

The core materials are the minimum required to accomplish office stream segment identification. Refer to Appendix A for equipment suppliers and supplemental resource contact information. USGS topographic maps provide the foundation for determining and documenting the distribution of channel types in the watershed. They are inexpensive and relatively easy to procure. These maps are also the standard for stream segment archiving and transfer of data to Geographic Information Systems (GIS). Note the edition date and make sure you have the most recent version. Make three high quality photocopies of the map sections that cover the stream's entire drainage basin area. Label one copy "TRIB/FINAL", another "GRADIENT", and the last "CONFINEMENT". Use a yellow highlighter and outline the stream and tributaries on the black and white photocopies for easier reference. An alternative is to use three pieces of Mylar overlay.

A gradient template and/or a map wheel are used to facilitate determination of channel gradient from topographic maps. Gradient templates are useful in situations where the stream channel is relatively

Core Office Materials and Equipment

- Copy master of Form 1 (Appendix B)
- Water Resource Inventory Area (W.R.I.A.) "Stream Catalog" basin section
- United States Geological Survey (USGS) topographic map(s) (7.5 minute)
- 3ea. b/w high quality photocopies (100% scale) of topo map w/stream and basin area
- 1ea. 24" x 36" Mylar for topo map(s)
- Map wheel
- Copy masters of Lump/Split Worksheets (Appendix C)
- Copy of 'Gradient/Quarter of Quarter template' on clear overhead film (Appendix H)
- "Scotch" tape; scissors; ruler; highlighter(s), pencils, colored pencils, and eraser

Supplemental Office Materials and Equipment

- Aerial photographs - individual (w/magnifying glass) or stereo pairs (w/stereoscope)
- Timber/Landowner road or resource maps
- GIS information (hydro, gradient, etc. layers)
- Water type maps
- Watershed Analysis Segment maps and reports
- Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP) Segment informa tion
- County/City flood, water and sensitive area resource maps/information
- Survey data from other resource agencies
- Washington Atlas & Gazetteer
- DNR/USGS Geology maps

straight. A gradient template is simply a straight baseline on a clear plastic sheet marked at intervals corresponding to the distances required to identify gradient breaks for a given contour interval and map scale. The baseline represents the stream channel if it were perfectly straight. NOTE: Always check your gradient template against the original topographic map scale for accuracy. Map wheels can be purchased in digital or mechanical dial formats and are useful for stream sections that are not as straight.

Supplemental information includes aerial photographs, ortho photographs, geology maps, DNR Hydro (GIS) maps, etc. These materials are not necessary, but should be used, if available, to increase the accuracy of segment boundary identification.

Supplemental information can provide increased resolution for determining segment boundary locations and discovering unique stream features not marked on the W.R.I.A. or topo maps. However, research and acquisition of supplemental information takes time so pre-planning is essential. These materials are also useful when designing a monitoring study and determining sub-segment boundaries. The list above does not cover all possible sources of information that can be useful for segmenting purposes.

Step 2: Make copies of the related stream's basin section narrative, drainage basin map, and stream number/name list.

Use the highlighter to mark the specific stream information for easy reference. The W.R.I.A. stream catalog (Williams et al., 1975) is no longer in print. Contact natural resource agencies in your area or TFW-MP for photocopies of desired stream information.

Step 3. Complete the header (except "Segment #") and "Stream Information" sections of Form 1.

W.R.I.A. #: Fill in the six digit Water Resource Inventory Area (W.R.I.A.) number. See Appendix E for example of a filled-out Form 1. This is one of two key pieces of information used to identify unique monitoring segments for the TFW-MP's database. The first two spaces are to record the basin's code number. The next four digits are to record the unique stream identification number. The first space in the single box is for recording a W.R.I.A. code letter if applicable (leave blank otherwise).

Unlisted Trib: Three spaces and RB/LB checks are provided after the W.R.I.A. code letter box to record unique identifiers for unlisted tributaries including springs. In these cases, start by recording the W.R.I.A. number of the stream the un-listed tributary flows into.

Use the three space box to assign a unique tributary number beginning with 001, 002, etc. (cooperator designated). If monitoring more than one unlisted tributary along the same main channel, remember to number them sequentially in order to create unique database and stream identification. Then fill in the appropriate circle to record whether the un-listed tributary enters the listed stream from the right bank (RB) or left bank (LB). TFW-MP right and left banks are always designated looking downstream.

Date: Enter the date the form is being filled-out. The date documents the time line of this portion of your monitoring plan. It also is a reference to the manual version used to segment the stream.

W.R.I.A. Stream Name: Enter the W.R.I.A. designated stream name. Use "Unnamed" where appropriate.

Other Stream Name: If different, enter the stream name(s) used on the USGS topographic maps and/or local name and source.

W.R.I.A. Basin Name: Enter the W.R.I.A. designated basin name. This name corresponds to the W.R.I.A. Basin number.

USGS Topographic Map Name(s): Map names are generally found in the upper right corner on 7.5 minute maps. Also note the map's edition date(s) in parentheses after the map name.

Project Manager, Manager Affiliation, and Data Affiliation: Enter the name of the person in charge of implementing the monitoring plan. This is the person others should contact to answer questions on how the study was done. Also record the manager and data affiliation. Manager affiliation is the tribe, company, or agency that the project manager directly works for and may be different from the data's affiliation, especially if a consulting firm. Data affiliation is the tribe, company, or agency that owns and houses the original data.

Step 4. Complete the header sections on all four Lump/Split (L/S) Worksheets.

Start by filling out the header information on the L/S worksheets using information from Form 1, USGS topographic maps, record the date of L/S worksheet use, and the name of the lead person filling it out.

EXAMPLE
John Creek is located along the western side of Hood Canal and is a tributary within the Hamma Hamma River Drainage. The catalog identifies this area as the Hood Canal Basin or W.R.I.A. 16. Next, the W.R.I.A. 16 map at the front of the chapter is used to determine which page the drainage information is found. The map for the Hamma Hamma Drainage is found on page 602 (Figure 1). The drainage map and the accompanying stream table are now used to locate the stream and its number. John Creek has stream number 0253 (Figure 2). The basin and stream number together provide a unique code for any stream statewide. John Creek's unique W.R.I.A. number is 16.0253. Use the W.R.I.A. information as the proper stream name and for identifying the tributary headwater. The USGS topo map name (North Branch Johns Creek) is noted in the "Other Stream Name(s)" space on Form 1.

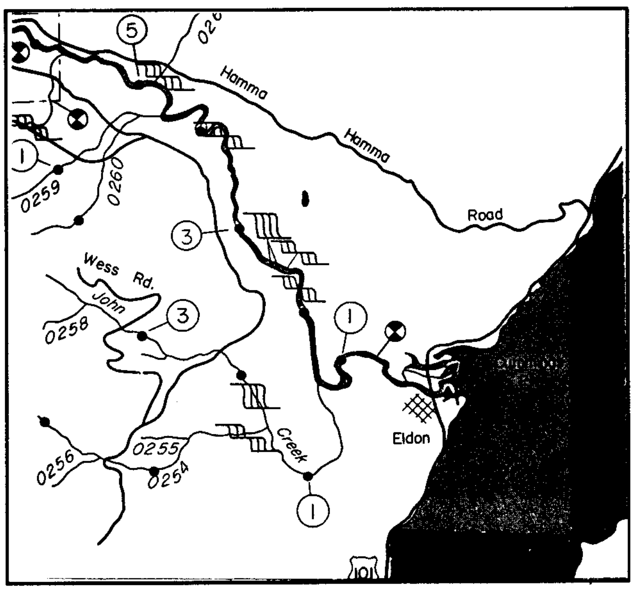

Figure 1. Detail of John Creek from the W.R.I.A. Stream Catalog of the Hamma Hamma River Drainage map.

Stream Number	Stream Name	Location Of Mouth	Length	Drainage Area	Salmon Use
0251	Hamma Hamma River	Sec27,T24N,R3W	17.8	84.6	Chin., Coho, Pink, Chum
0253	John Creek	RB-1.4	3.9	4.38	Coho, Pink, Chum
0254	Unnamed	RB-1.5	2.1	—	Unknown

Figure 2. Detail of the stream number table from the W.R.I.A. Stream Catalog showing John Creek information.

2.2 Layer 1: Tributary Junction and Non-fluvial Feature Segment Breaks

The first factors used in the stream segment identification process are segment breaks based on tributary junctions and non-fluvial features. This section is used to identify potential break points along the stream channel where: a) significant tributary junctions change flow conditions and stream characteristics; and b) stream conditions are not dominated by channel-forming (fluvial) processes. Tributaries supply additional water, sediment, and large woody debris (LWD) loads which result in changes to channel morphology. Consequently, channel characteristics often change below the confluence of significant tributaries (Richards, 1980).

Current TFW-MP methods are designed for monitoring channel sections that function under typical channel-forming (fluvially-dominated) processes. Therefore, it is important to also identify non-fluvial features including lakes, wetlands and human-created features such as reservoirs, long culverts and water intake facilities that occur in stream systems. This category also covers anomalous fluvial features such as large falls, channels through wetlands, areas of tidal influence and tributaries with summer flow channels within the bankfull of larger streams.

Step 1: Identify and mark stream orders on the "TRIB/FINAL" map photocopy.

Determine the stream order of the channels using the Strahler method (Dunne and Leopold, 1978)(Figure 3). In this drainage system, small headwater streams that have no tributaries are designated as first-order streams. Where two first-order streams meet they form a second-order stream. Where two second-order streams join they form a third-order stream, and so forth. The stream order changes only when two streams of equal order meet, so the confluence of a lower order tributary does not alter the order of a larger stream.

The USGS 7.5 minute topographic map is the standard for consistently assessing which tributaries are included as part of this procedure. These maps provide the most evenly applied set of criteria for identifying the most significant watershed tributaries. Tributaries with perennial flow are denoted by solid blue lines and those with intermittent flow are denoted by dashed or thin blue lines. Segmenting based on tributary junctions that are not marked on the USGS maps are covered in the "**Sub-Segment**" section later.

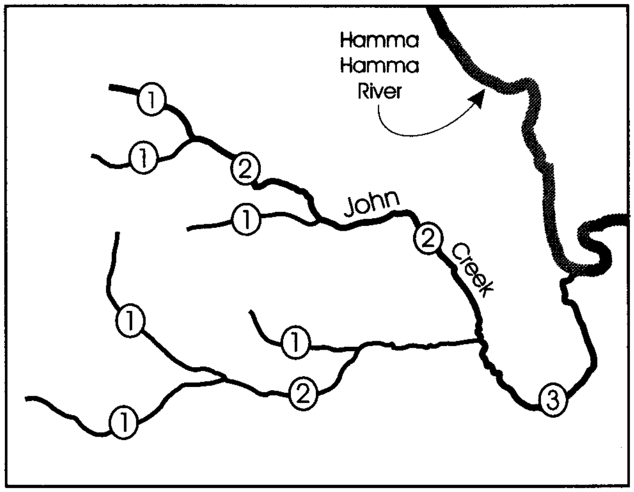

Figure 3. John Creek drainage system delineated by stream order using the Strahler method.

If the stream reach you are interested in monitoring is not shown on the USGS map, then check alternate sources such as aerial photos, DNR water type maps or GIS Hydro layer. Transfer the information to the

TRIB/FINAL map photocopy. Next, draw in the drainage network upstream from where the new stream enters one shown on the USGS map. This is accomplished by extending the traced channel lines upstream into all contour crenulations, swales, and marshlands on the USGS topographic map photocopy (Dunne and Leopold, 1978). Stream orders and tributary junctions can then be identified and marked using the Layer 1 steps outlined above.

The alternative stream order number typically does not reflect USGS topo map ordering and should not be used to change the orders of streams it flows into. In these situations, basin area is the best representative parameter for identifying comparable segment characteristics. The stream network shown on water type and hydro layer maps is not to be used for stream order break information due to the non-standardized way stream information is derived, and the biased nature of stream typing identifying only those stream with salmonid presence.

Step 2: Identify and mark segment breaks based on tributary junctions on the "TRIB/FINAL" map photocopy.

Mark tributary junction breaks along the stream where:
a) the tributary stream order is the same as the main channel; and
b) the tributary is one order smaller than the main channel up to stream order 3; and
c) the tributary is two stream orders smaller than the main channel on stream order 4 or greater stream sections.

Stream order delineation is a simple way to detect relationships in tributary drainage basin sizes. The criteria is designed to delineate stream segment breaks at tributaries that contribute 10% or more of the total upslope drainage area (WFPB, 1995a). Segment breaks can be justified on the basis of basin area in situations where the topographic map stream order does not reflect relative drainage basin size. For example, a tributary with a stream order of one can be increased to reflect the stream order of similar size basin areas in the watershed. However, the estimated tributary stream order is never used to change the stream order below that point. If in doubt about a tributary's stream order, use a pencil and draw the outline of representative basins by tracing along the ridge tops and compare them to the one in question.

Side channels are most often identified during field verification, but may be large enough in some situations to appear on a topo map or in supplemental information. At a minimum, main and side channel segment breaks can be placed at the upstream exit and downstream re-entry points if the side channel meets the following criteria: a) it is separated from the main channel by an island; b) it has a length greater than 200 ft.; c) it has a bankfull width of 10% or more of the total (main + side bankfull channel width) and/or it has at least one different gradient or confinement category. Side channels that do not meet this criteria may be suitable for sub-segmenting.

EXAMPLE 2.2A
John Creek is divided into four tributary-based segments using the criteria above (Figure 4). From the mouth upstream: a) the upper boundary of the first segment is at the junction of the second order "South Branch" tributary and the second order main channel; b) the upper boundary of the second segment is at the junction of the first order unnamed tributary stream and the second order main channel; c) the upper boundary of the third segment is at the junction of the first order unnamed headwater tributary and the first order main channel; and d) the upper boundary of the fourth segment is at the headwaters of John Creek.

EXAMPLE 2.2B
Larger stream systems such as the White River commonly have large side channels that can be segmented (Figure 5). In this situation, there are two side channels which appear to meet the three criteria in Step 2. Segmenting the side channels allows monitoring information collected within their channels to be analyzed according to their hydrologic and geomorphic characteristics.

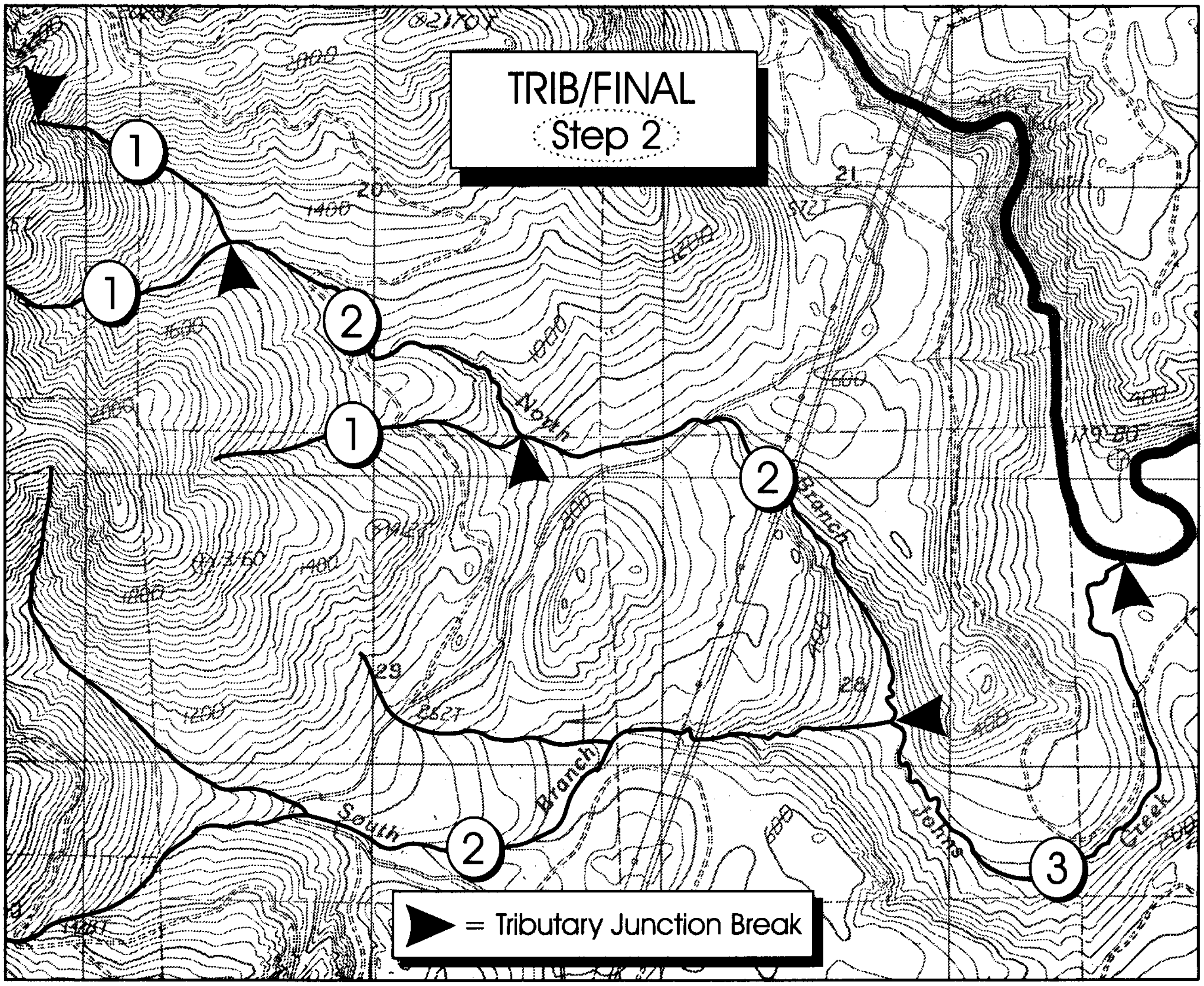

Figure 4. Detail of John Creek showing segment break placement based on tributary junction criteria.

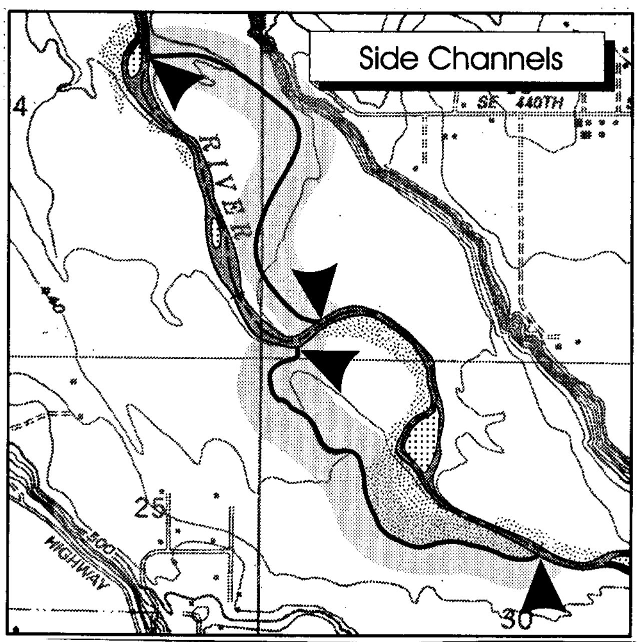

Figure 5. Detail of two side channels along the White River showing segment break placement based on side channel criteria.

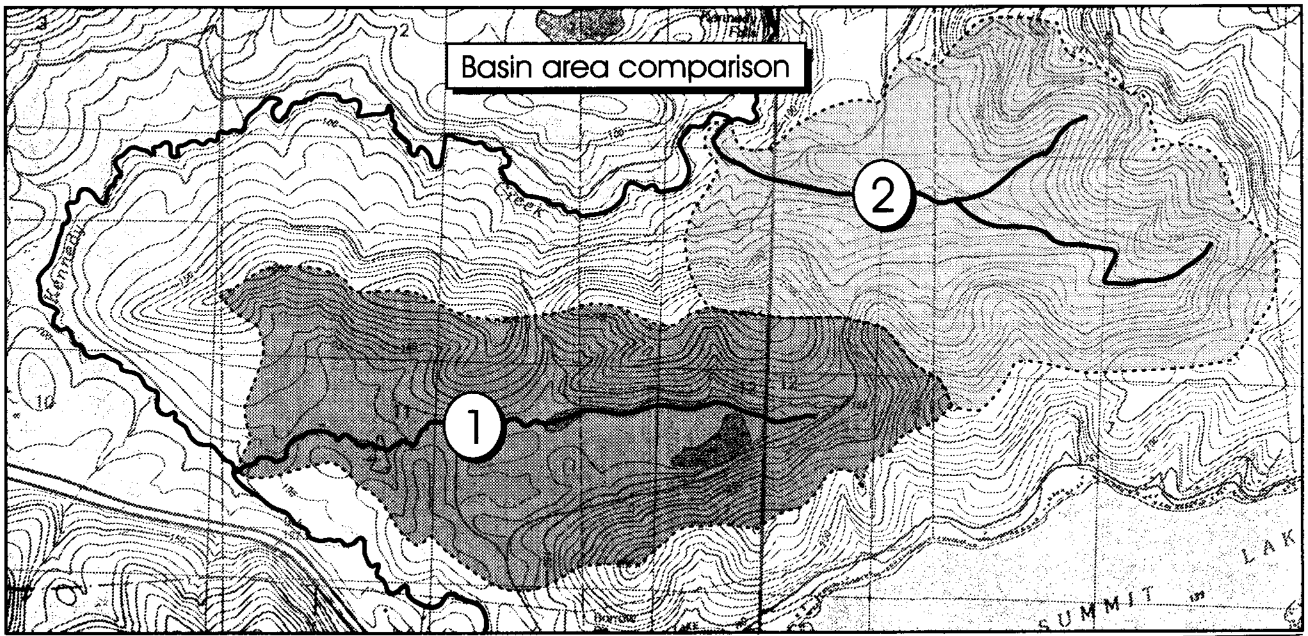

Figure 6. Detail of Kennedy Creek showing comparisons of similar basin areas with different stream orders.

> *EXAMPLE 2.2C*
> A first order unnamed tributary drains into the main channel of Kennedy Creek (third order) (Figure 6). Comparison of the unnamed tributary's basin with other similar size basins in the Kennedy Creek watershed indicates that it drains an area similar to second order tributaries. Therefore, a stream order of 1 does not accurately reflect drainage basin size so it is assigned a stream order of 2 and its estimated order is used to assess a segment break.

Step 3: Identify and mark segment breaks based on non-fluvial stream features on the 'TRIB/ FINAL' map photocopy.

This step only identifies riverine associated (directly connected) waterbodies where surface water conditions are not dominated by channel-forming (fluvial) processes. These surface waters include wetlands, lakes, ponds, estuaries, and public water supply facilities. Refer to the Watershed Analysis Water Quality Module (WFPB, 1997) and the Washington Forest Practices Board Manual (WFPB, 1995b) for more information on waterbody and water supply identification and classification. For purposes of office segment identification, follow the guidelines listed below as a first cut for waterbody typing.

Lacustrine Systems

The Lacustrine System includes permanently flooded lakes and reservoirs, intermittent lakes, and tidal lakes with ocean-derived salinities below 0.5 %. Typically, surface area is greater than 20 acres, there are extensive areas of deep water (> 2 meters), and there is the potential for considerable wave action. Lacustrine Systems formed by damming a river channel are bounded by a contour approximating the normal spillway or outlet depth elevation. Where a stream enters or exits a lake, the extension of the Lacustrine shoreline forms the boundary (Cowardin et al., 1979). Note: check the WDFW Stream Catalog for streams which are assigned different numbers below and above a lake. A segment can never span two different W.R.I.A. numbers.

Riverine Wetlands

Wetlands are transitional areas between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowardin et al., 1979). Explicit in this definition is the consideration of three environmental parameters: wetland hydrology, hydric soils, and hydrophytic vegetation. Observable evidence of all three parameters normally is present in wetlands (WFPB, 1995b). Typically, minimum wetland size is 0.5 acres (21,780 ft^2/2,024 m^2), but may be as small as 0.25 acres (10,890 ft^2/1,012 m^2) (WAC 222-16-035). Where a stream enters or exits a wetland, the extension of the wetland edge forms the boundary.

If the stream flows through a wetland (e.g., marsh, bog, fen, or swamp), use the topographic maps and aerial photographs to identify and mark the boundaries. With aerial photographs, the boundaries of wetlands can sometimes be detected through changes in vegetative composition and structure such as distinct changes from conifer to deciduous trees, trees to shrubs or grasses, and differences in canopy density. Other good information sources for identifying wetlands are DNR Hydro GIS layers, National Wetland Inventory maps, and county government wetland or sensitive area maps.

Estuaries, Lagoons, and Areas of Tidal Influence
Tidal influence extends from an imaginary line closing the mouth of a river or creek upstream and landward to where ocean-derived salts measure less than 0.5% during the period of average summer low flow (Cowardin et al., 1979). The upper boundary is typically at a point corresponding to the landward limit of tidal influence. In these type situations, water flows are dominated by tidal influences with water depths and velocity controlled by tidal cycles. Similar to wetland boundary identification, this can be done using aerial photographs and observing vegetative indicators. Look for changes in vegetative composition and structure such as distinct changes from trees to shrubs or grasses and differences in canopy density.

Public Water Supply Facilities and Other Non-Fluvial Features
To address other non- or anomalous fluvial features use strategies similar to those for lakes, wetlands and tidally influenced areas. Upper segment breaks on non-fluvial stream sections (reservoirs, long culverts, city water intake facilities, etc.) must reflect the upper most extent of back-flow impact including that from winter flood waters. Culverts greater than 400 feet or 100 meters long are treated as segments. Shorter culverts can be sub-segmented if they cause localized fluvial disturbance or as part of a culvert assessment process.

EXAMPLE 2.2D
Elk Lake is a non-fluvial feature found along Jefferson Creek on the Olympic Peninsula (Figure 7). Segment breaks are placed at the downstream exit and upstream entry points. This system helps to define the boundaries of non-channel monitoring areas.

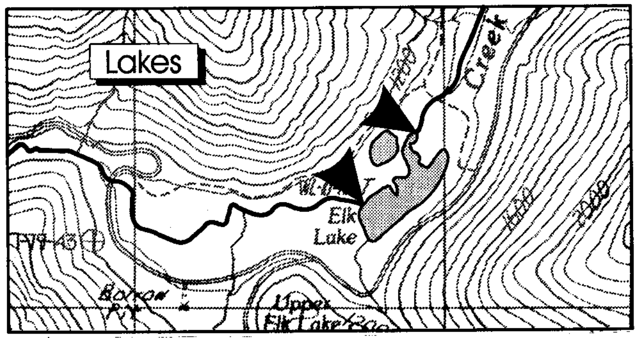

Figure 7. Detail of Elk Lake on Jefferson Creek showing segment break placement.

EXAMPLE 2.2E
Frame and Bear Creeks have wetland systems identified on the topographic map through symbols and shading patterns (Figure 8). Segment breaks are placed where the extension of the wetland edge intersects the stream channel at both the downstream exit and upstream entry points.

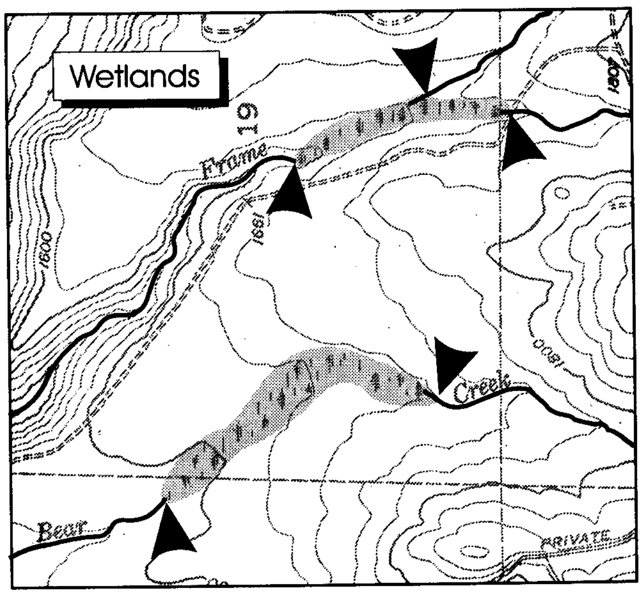

Figure 8. Detail of wetland areas on Frame and Bear Creeks and placement of segment breaks.

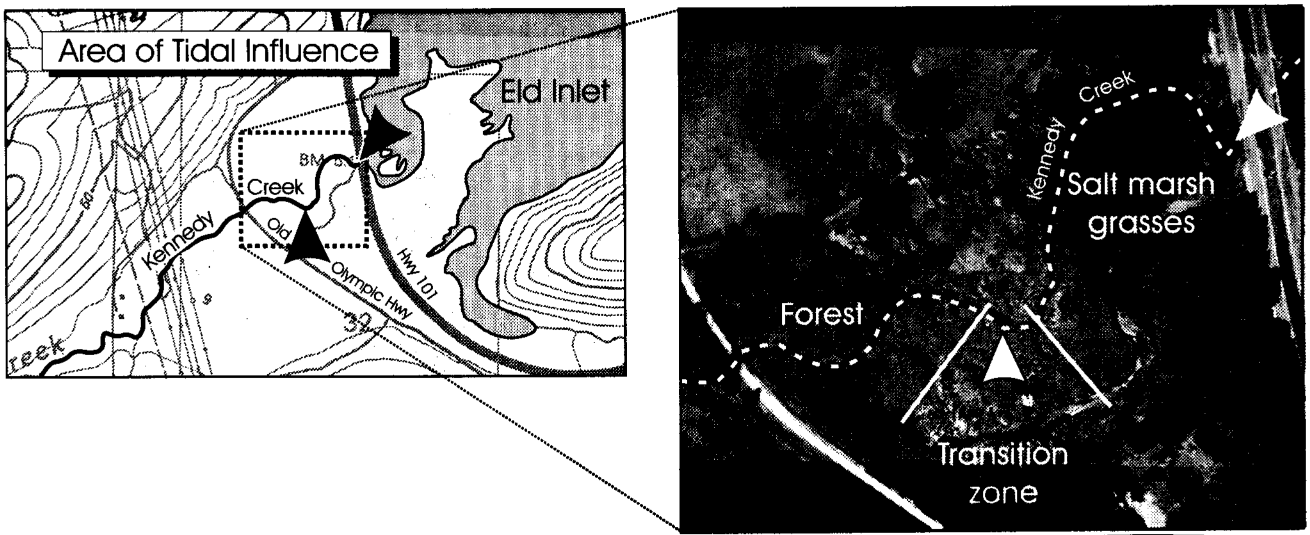

Figure 9. Detail of tidal influence area along Kennedy Creek and placement of segment breaks.

EXAMPLE 2.2F
Kennedy Creek drains in to Eld Inlet at the southern end of Puget Sound (Figure 9). Segment breaks are placed at the mouth located at the stream side of the Highway 101 bridge and upstream at the point where tidal hydrology and water salinity meet the criteria. In this situation, a magnified aerial photograph was used to observe vegetative indicators that represent changes between forested and estuarine plant communities. A transition area was identified and a point halfway between was selected for the segment break point.

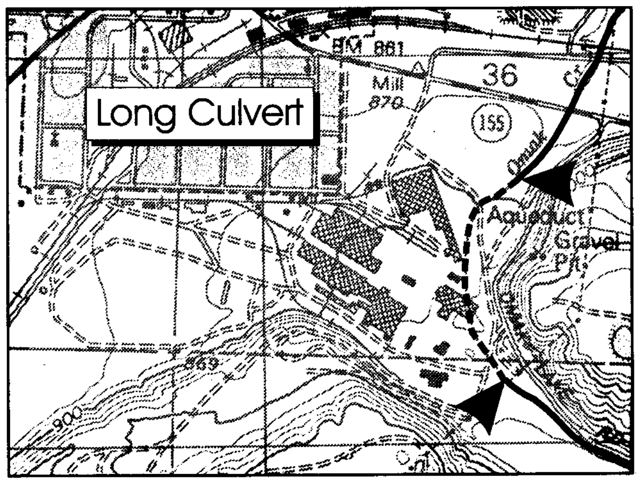

Figure 10. Detail of Omak Creek culvert location (heavy dashed line) and placement of segment breaks.

EXAMPLE 2.2G
Omak Creek flows into the Okanogan River in the northeastern section of Washington. In its lower section, an approximately 700 meter length of the channel flows within a long culvert below the property of a timber mill operation (Figure 10). Segment boundaries are placed at the estimated entry and exit points along the stream.

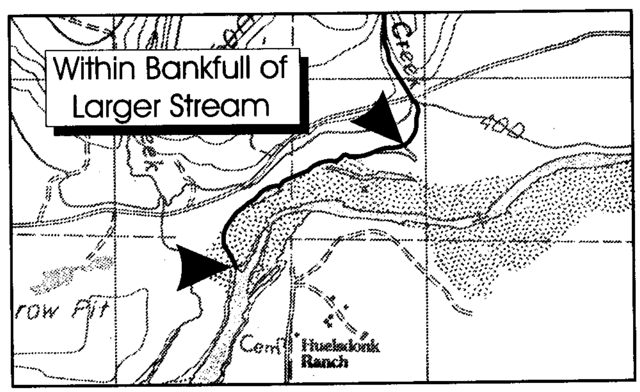

Figure 11. Detail of inter-bankfull area along Canyon Creek and placement of segment breaks.

EXAMPLE 2.2H
Canyon Creek flows into the Hoh River on the Olympic Peninsula. The lower section of the stream channel appears to lie within the bankfull width of the larger stream (Figure 11). In these situations, use the same procedure as in a tidally influenced area.

Step 4: Transfer Layer 1 segment information to the "Tributary/Non-Fluvial Break Lump/Split Worksheet".

These L/S worksheets greatly simplify the decision-making process and documentation of lumping and splitting segment breaks on each layer. It is also a useful field verification tool for identifying the location of likely channel anomalies. Always leave the "Seg #" column on each L/S worksheet blank until after completion of the lumping/splitting process.

Consecutively list all the tributary/non-fluvial segments beginning at the mouth and working upstream. Record the stream order for each segment or identify the non-fluvial feature. "Length" column information is used only for resolving close lumping and splitting questions. Use the "Notes" column to record segment information including supplemental sources used. The "Page __ of __" in the upper right corner of the worksheet documents how many "Tributary/Non-Fluvial Break" worksheets were used in this process. If only one was needed, then put "Page 1 of 1".

EXAMPLE 2.2I
John Creek is divided into four tributary junction-based segments (Figure 4). • The lowest segment has a stream order of 3 and its upper boundary is located where the "South Branch Johns Creek" tributary (W.R.I.A. # 16.0254) enters on the right bank at approximately river mile 1.5. • The second segment has a stream order of 2 and its upper boundary is located at the junction of an unnamed and unlisted tributary entering on the right bank at approximately river mile 2.8. • The third segment also has a stream order of 2 and its upper boundary is located at the junction of a headwater tributary (W.R.I.A. # 16.0258) entering on the right bank at approximately river mile 3.6. • The fourth segment has a stream order of 1 an comprises the remaining length of channel to its headwaters. Refer to Appendix E for an example of a filled-out worksheet.

Step 5: Lump and split tributary and non-fluvial segment breaks.

Splitting: Tributary-based segments are split out (stand alone) in situations where their breaks are greater than or equal to 400 feet or 100 meters from each other. Non-fluvial features are split out if they meet the criteria listed in Step 3. EXCEPTIONS:
a) the mouth of a stream can have a minimum length of 200 feet or 100 meters regardless of gradient category; and b) streams with bankfull widths larger than 65 feet or 20 meters can use longer minimum distances.

Lumping: Lump (combine) tributary breaks that do not meet the minimum distance criteria: a) toward the closest same-order tributary junctions; or b) in a direction that supports identification of the largest segments with similar flow-inputs. Lump non-fluvial breaks towards closest tributary break.

EXAMPLE 2.2J
The headwaters of an unnamed tributary to Waketickeh Creek has four stream order 1 tributaries entering (Figure 12). For this example they are labeled "Trib a, b, c, and d". The segment below "Trib a" meets minimum length criteria, but distances between "Trib a/b" and "c/d" do not. "Trib c" (1 into a 2) is lumped into "Trib d" which is a same-order junction (1 into a 1). "Trib b" is lumped into "Trib a" as it supports identification of a large similar flow segment between the mouth and "Trib a". This process serves to lump irregular stream sections together into segments.

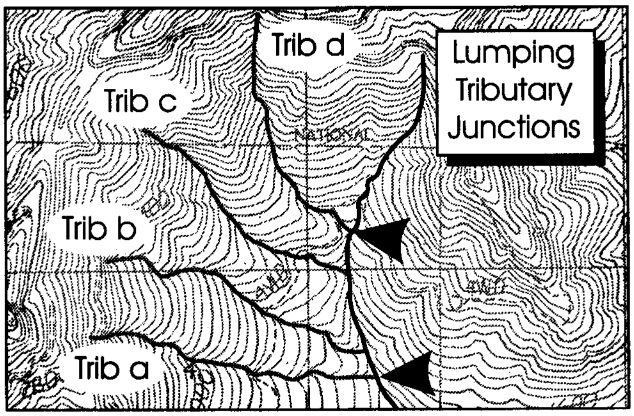

Figure 12. Detail of Waketickeh Creek trib showing segment breaks based on lumping criteria.

2.3 Layer 2: Channel Gradient Segment Breaks

Channel gradient is the second factor used in the stream segment identification process. Segment breaks are placed at 1%, 2%, 4%, 8% and 20% channel gradient changes. These gradient breaks are compatible with the Watershed Analysis Stream Channel Assessment Module.

Step 1: Identify and mark the intersection of every contour line with the stream on the "GRADIENT" map photocopy.

Topographic contour lines are typically brown in color and portray the general valley shape and channel elevation changes along the length of the stream. The distance along the stream between two contour lines is called the contour interval.

Refer to the original topo map often when using a black and white map photocopy, as color differences can help identify line crossings in complex areas. Use a colored pencil with a fine point. Start at the mouth of the stream and mark the first downstream contour line of the stream it flows into. If the mouth of the stream is in or near a tidal area (no contour lines cross below mouth), place a mark along the stream representing the landward limit of tidal influence. Return to the mouth of the stream and work upstream marking where each subsequent contour line crosses the blue stream channel line.

EXAMPLE 2.3A

The mouth of John Creek flows into the Hamma Hamma River at a point below the first contour line (Figure 13). A mark is placed representing the landward limit at which tidal influence no longer significantly affects the stream's normal fluvial processes. This point was estimated using vegetative indicators visible on aerial photographs. In this case, the vegetative indicator was the change from salt marsh to forest. • Returning back to John Creek, the first upstream contour line crossing is located just above the word "Creek" and the next just before the word "Johns" (USGS stream name) (Figure 14). • Working upstream, the contour intervals become smaller above the south branch tributary junction then vary above the 640 foot elevation line where the road crosses. • Finally, the contour intervals become very close together at the headwaters ending at the 2160 foot elevation line.

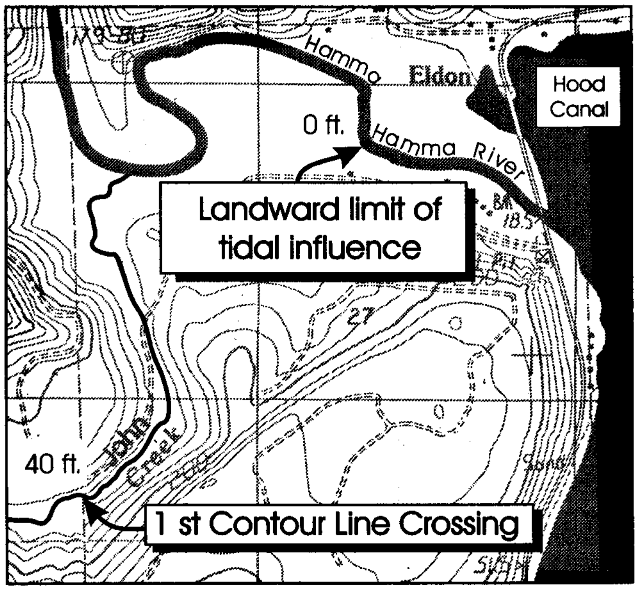

Figure 13. Detail of lower John Creek and the Hamma Hamma River showing locations of the zero elevation and the first contour line crossing.

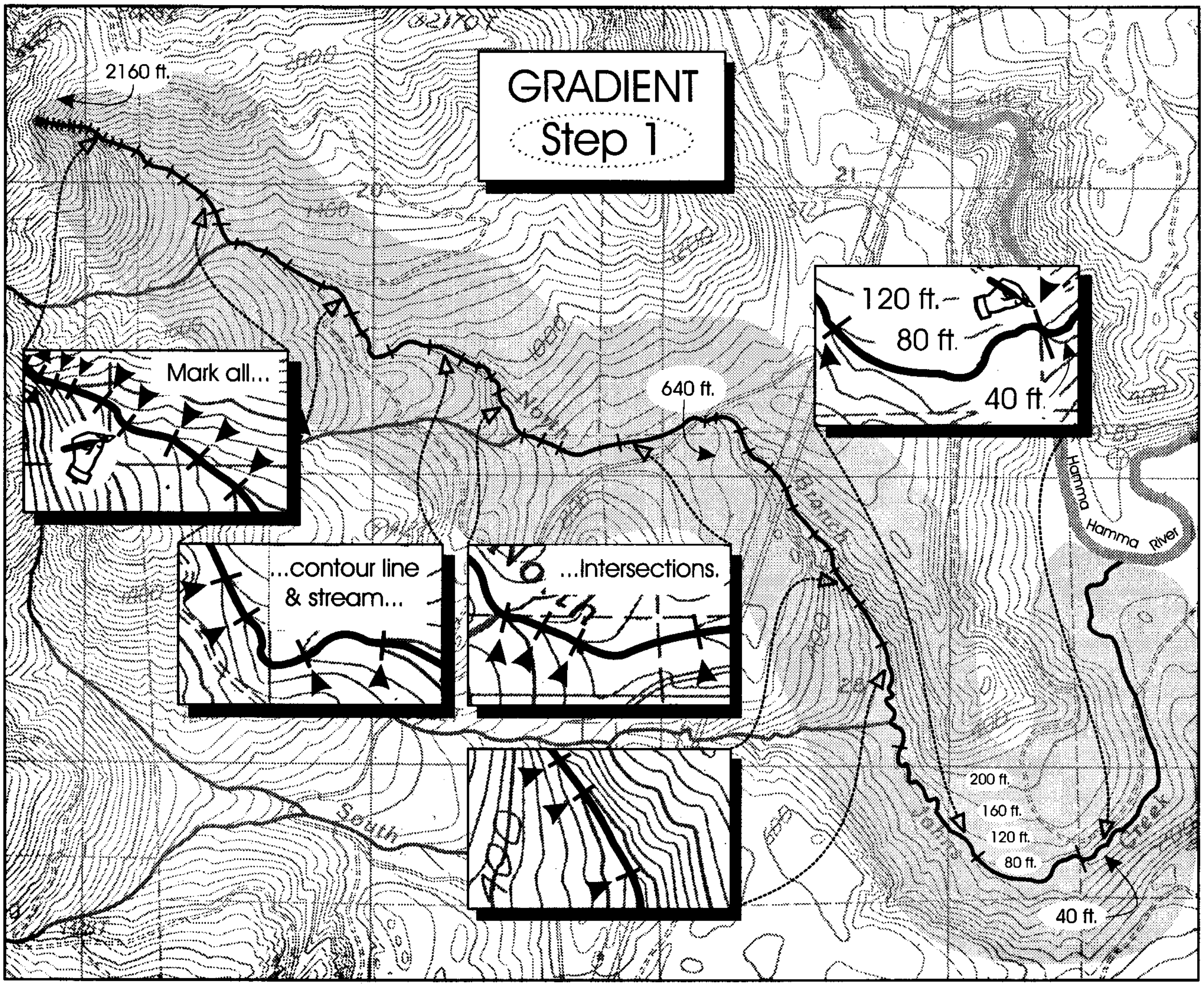

Figure 14. Detail of John Creek and marking technique at contour line crossings.

Step 2: Identify and mark segment breaks based on channel gradient on the "GRADIENT" map photocopy.

This step involves two procedures. First, determine the channel gradient between individual contour lines. Then, mark potential segment breaks at those contour lines where the upstream gradient and the downstream gradient fall into different gradient break categories (Table 2).

Channel gradient is determined using contour lines on maps to provide elevation (rise) information and a gradient template or map wheel to measure contour interval distance (run). Then, channel gradient is calculated by dividing the rise over the run between each contour line intersection along the length of the channel (Figure 15). Most USGS 7.5 minute maps have contour intervals of either 20 feet, 40 feet or 10 meters. This means that every time a contour line crosses the channel, there is a rise in elevation between the lines equal to the map's contour interval.

Table 2. Gradient break categories for stream segments.

Gradient Break Categories
≤ 1%
> 1% and ≤ 2%
> 2% and ≤ 4%
> 4% and ≤ 8%
> 8% and ≤ 20%
> 20%

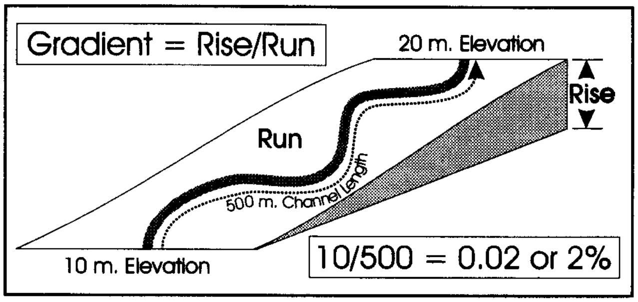

Figure 15. Gradient is calculated by dividing the rise in elevation by the run between two points along the length of a channel.

Table 3 provides information on using rise over run to calculate important gradient break points. Contour line information is located at the bottom center of the map just below the 'Scale' markers. CAUTION: Always check contour interval scale before proceeding - contour interval scales are often not standard for adjacent USGS topographic maps.

Table 3. The length of stream between the contour lines (run) required to produce 1%, 2%, 4%, 8% and 20% gradients for a given contour interval (rise).

Gradient	Contour Interval (Rise) 40 feet	20 feet	10 meters	
1%	4000 ft.	2000 ft.	1000 m	Stream Length between Contour Lines (Run)
2%	2000 ft.	1000 ft.	500 m	
4%	1000 ft.	500 ft.	250 m	
8%	500 ft.	250 ft.	125 m	
20%	200 ft.	100 ft.	50 m	

Select the proper gradient template based on the map's contour interval and scale. If your map is not a 1:24,000 scale, use a map wheel or construct your own gradient template. The distance marks along the right-hand side of the baseline correspond to the minimum length required for the percent gradient marked on the left side of the baseline (Figure 16). These are related to the distance between each perpendicular hash mark along the baseline - they are *not* cumulative distances. Start by overlaying the template along the stream channel and determine which range of distances are represented between contour lines. It may be necessary to carefully "walk" the baseline along the curves of the stream in situations where the distance is close to a break interval. A map wheel is the best tool to determine interval distances in situations where the channel is very sinuous. On a 40 foot Contour Interval map, an interval distance greater than or equal to (≥) 4,000 feet would correspond to a gradient category of less than or equal to (≤) 1%. An interval distance < 4,000 feet but ≥2,000 feet would correspond to a gradient category of 1 to ≤ 2%, and so forth.

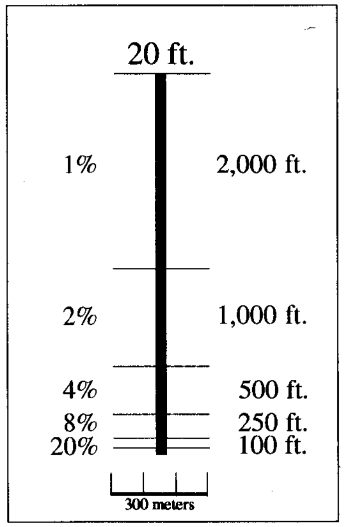

Figure 16. Example of a gradient template used with a USGS 7.5 minute 1:24,000 scale topographic map and having 20 ft. contour intervals.

EXAMPLE 2.3B

John Creek is located on the Eldon USGS 7.5 minute topographic map (40 foot contour interval at the 1:24 000 scale). The distance along the stream between the Hamma Hamma River tidal mark and the first contour line crossing John Creek is definitely over 4,000 feet (Figure 17). This means that the channel gradient category between the mouth and first contour line is ≤ 1%. • The distance along the stream for the next interval is definitely greater than 1,000 feet, but less than 2,000 feet which corresponds to a gradient category of 2 to ≤ 4% (Figure 18). Since the gradient categories are different above and below the first contour line, a segment break mark is placed here. • The next two intervals also have 2 to ≤ 4% gradient categories. • The next interval above the tributary junction is exactly or just more than 500 feet. A 40 foot rise over a 500 foot distance equals 8% and this fits into the gradient category of 4 to ≤ 8%. • The next series of intervals have distances equal to or greater than 200 feet but less than 500 feet so they are all in the 8 to ≤ 20% gradient category. • Using this process, there are a total of 19 individual or adjacent category groupings for John Creek.

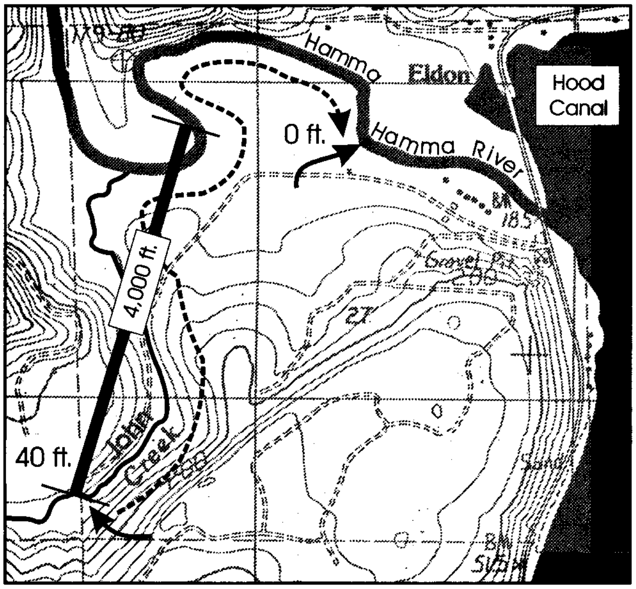

Figure 17. Detail of lower John Creek and gradient template showing greater than a 4,000 foot run between the zero and 40 foot elevation points.

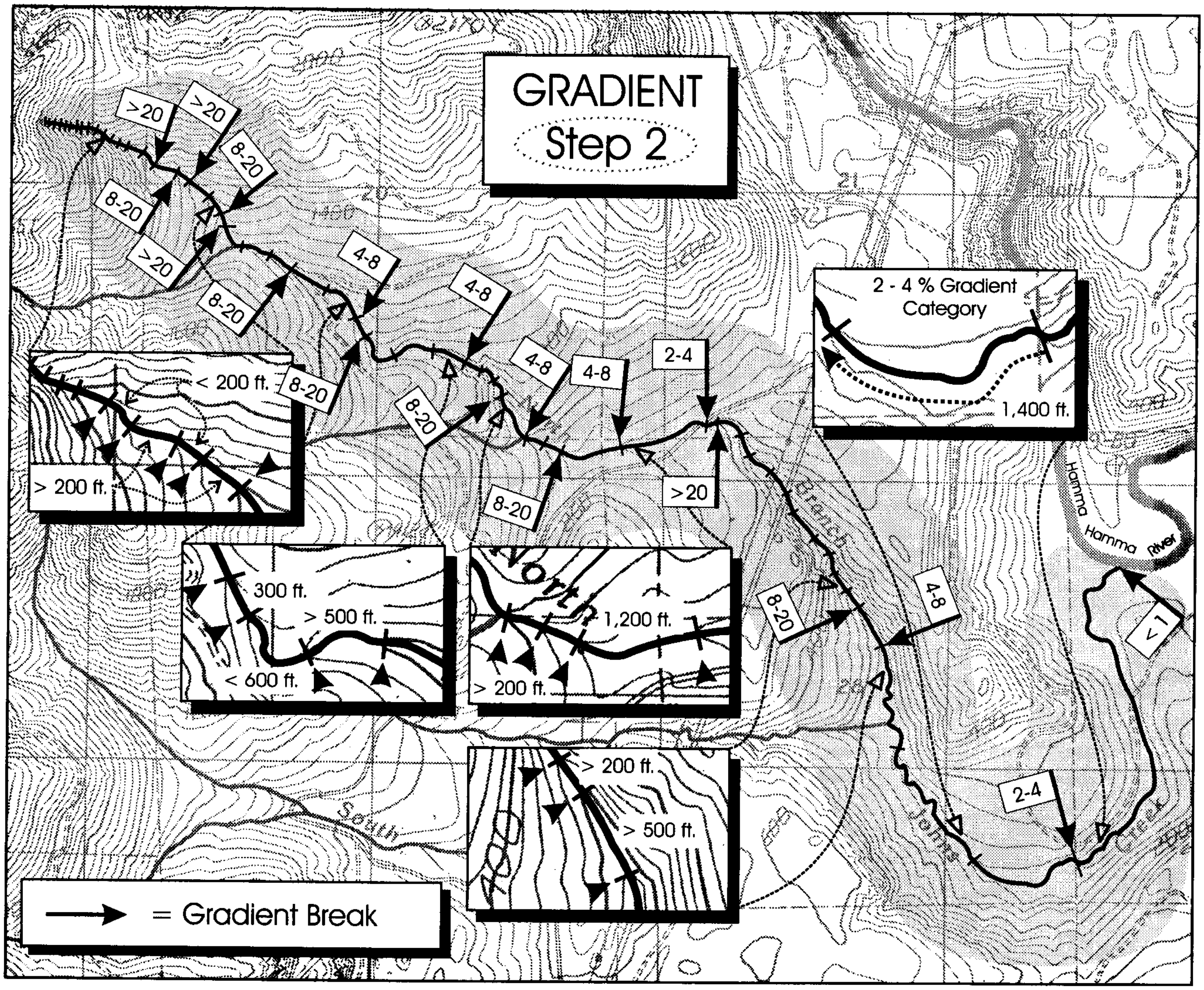

Figure 18. Detail of John Creek showing channel gradient category changes from the mouth to headwaters.

Step 3: Transfer Layer 2 segment information to the "Channel Gradient Break Lump/Split Worksheet".

Consecutively list all the gradient categories and the number of contour intervals represented in the "Grad Cat" and "# CI" columns respectively beginning at the mouth and working upstream (Figure 19). "Length" column information is used only for resolving close lumping and splitting questions. Use the "Notes" column to record information on gradient breaks including supplemental sources used.

Seg #	Grad Cat	# CI	Length	Lump/ Split
	< 1	1		
	2-4	3		
	4-8	1		
	8-20	10		

Figure 19. Example of Step 3, transferring information to the "Channel Gradient Break Lump/Split Worksheet."

Step 4: Lump and split channel gradient segment breaks.

This procedure uses criteria based on minimum segment length and/or number of contour intervals (Table 4). The purpose of the criteria is to provide a format for consistently determining which gradient-based segments are split out (divided/separated) and which ones are lumped (combined). This criteria is based on topographic map accuracy and the likelihood of finding a homogeneous length of channel gradient. The length column corresponds to the total length of one or more similar adjacent gradient category segments to the nearest 100 feet or meters. The contour interval number (# CI) column corresponds to the total number of similar adjacent gradient category intervals.

Splitting: Any segment with two or more contour intervals qualifies as an individual segment. Segments with less than two contour intervals are evaluated using the criteria found in Table 4. First, select the proper contour interval column based on the topo map scale (40 ft., 20 ft., or 10 m). Next, find the appropriate gradient category row along the left hand side of the table. EXCEPTIONS: a) The mouth of a stream can have a minimum length of 200 feet or 100 meters regardless of gradient category; and b) Streams with bankfull widths larger than 65 feet or 20 meters can use longer minimum distances.

Table 4. Criteria for lumping and splitting channel gradient breaks based on minimum segment length and number of contour intervals (CI) for USGS 7.5 minute topographic maps with 40 foot, 20 foot, and 10 meter contour intervals.

Gradient	40 ft.		20 ft.		10 m.	
	Length	# CI	Length	# CI	Length	# CI
≤ 1%		1		1		1
1 to ≤ 2%		1		1		1
2 to ≤ 4%		1	≥ 1000 ft.	1	≥ 300 m.	1
			< 1000 ft.	2+	< 300 m.	2+
4 to ≤ 8%	≥ 600 ft.	1	≥ 400 ft.	1	≥ 200 m.	1
	< 600 ft.	2+	< 400 ft.	2+	< 200 m.	2+
8 to ≤ 20%	≥ 400 ft.	1	≥ 200 ft.	1	≥ 100 m.	1
	< 400 ft.	2+	< 200 ft.	2+	< 100 m.	2+
> 20%		2+		2+		2+

Lumping: Single gradient category intervals that did not meet the splitting criteria must be lumped to adjacent segments. Always work from the mouth upstream to the headwaters. This process uses a progressive set of lumping criteria that is applied sequentially until it meets the requirements of that level. For each lumping decision situation, the interval is lumped with:

1) an adjacent same gradient category;
   - if not available, then...
2) the next highest category without skipping;
   - if not available, then...
3) the next lowest category without skipping;
   - if not available, then...
4) the category with the greatest number of contour intervals;
   - if not available, then...
5) the category with the longest contiguous length.

EXAMPLE 2.3C
40 foot contour intervals: Segments with either ≤ 1%, 1 to 2%, or 2 to 4% gradients have no minimum criteria for length or number of contour intervals and are split out. Segments with 4 to 8% gradients must have a minimum length of 600 feet or two contour intervals to be split out. Segments with 8 to 20% gradients must have a minimum length of 400 feet or two contour intervals to be split out. The > 20% gradient category must have a minimum of two consecutive intervals to be split out, but there is no minimum length.

EXAMPLE 2.3D
In the John Creek example, a single interval with a gradient category of ≤ 1% does not have a minimum length and is split (Figure 20). This is noted on the L/S worksheet by placing an "S" in the "Lump/Split" column on that row. The second grouping of intervals with gradient categories of 2 to 4% also have no minimum length requirements and are split. The third single 4 to 8% category interval length must be measured to see if it meets the minimum of 600 feet. It is only 500 feet long so this must be lumped later. This is noted on the L/S

EXAMPLE 2.3D (cont.)
worksheet by placing an "L" in the "Lump/Split" column. Working upstream on the L/S worksheet, 12 of the 19 gradient category groups can be split out. Refer to Appendix E for an example of a completed worksheet.

Seg #	Grad Cat	# CI	Length	Lump/ Split
1	< 1	1		S
2	2-4	3		S
	4-8	1	500	L
3	8-20	10		S
	>20	1	150	L
4	2-4	1		S
5	4-8	1	700	S
6	8-20	2		S
7	4-8	1	600	S
8	8-20	4		S
9	4-8	2		S
	8-20	1	200	L
	4-8	1	500	L
10	8-20	4		S
	>20	1		L
	8-20	2		S
	>20	1		L
	8-20	1	200	L
11	>20	10+		S

Figure 20. Detail of John Creek information from the "Channel Gradient Break Lump/Split Worksheet".

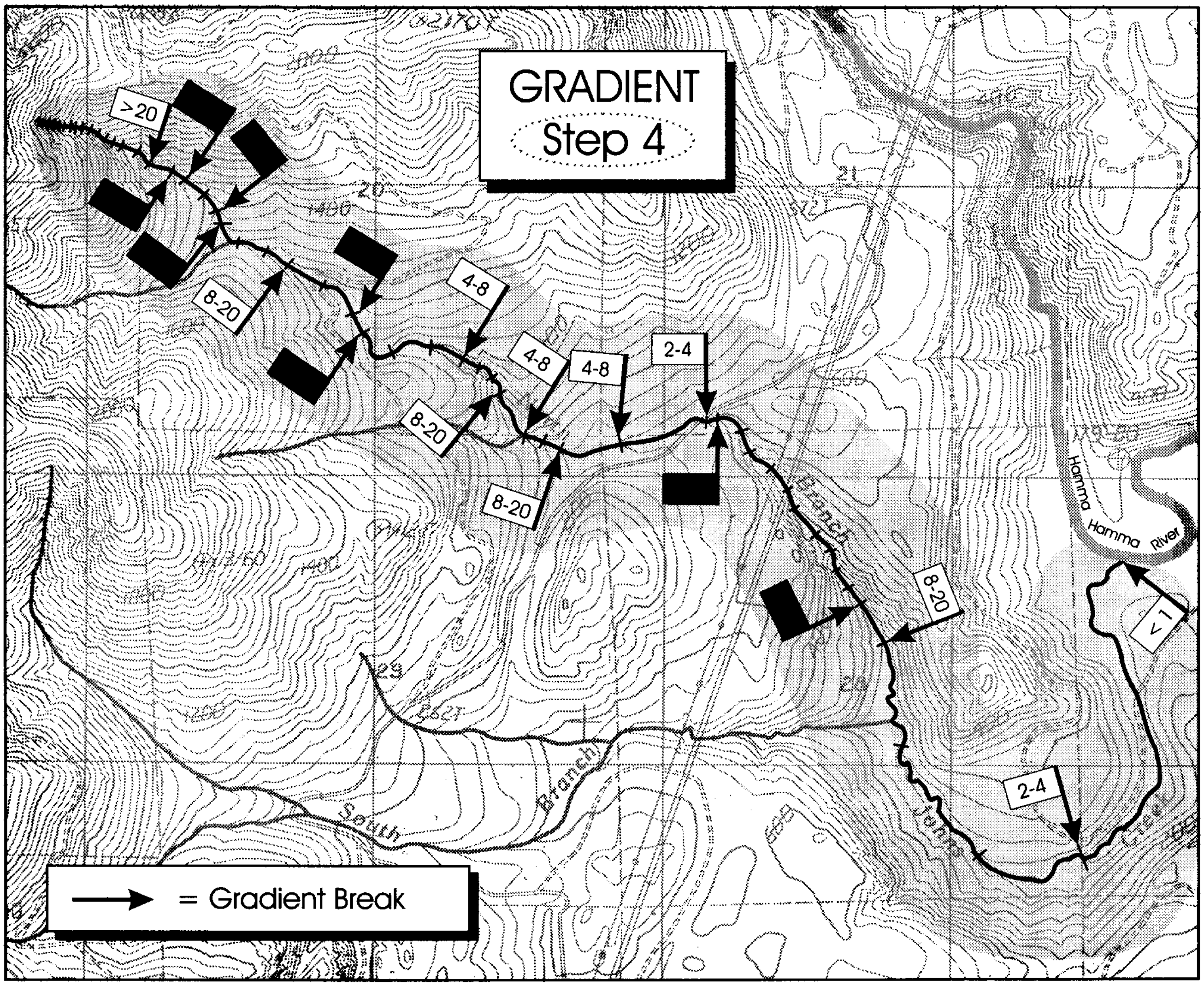

Figure 21. Detail of John Creek showing final channel gradient segment break locations and categories from the mouth to headwaters.

EXAMPLE 2.3E

In the John Creek example, a single interval with a 4 to 8% gradient category must be lumped to either the downstream 2 to 4% group or the upstream 8 to 20% group (refer to Figures 20 and 21). Following lumping criteria: 1) there are no adjacent 4 to 8% categories; 2) there is a next highest category without skipping. STOP LUMPING PROCESS HERE. Lump the 4 to 8% group with the upstream 8 to 20% group. • Next, a single > 20% interval must be lumped to either the downstream 8 to 20% group or the upstream 2 to 4% group. Following the criteria above: 1) there are no adjacent > 20% categories; 2) there are no next highest categories; 3) there is a next lowest category without skipping. STOP. Lump the > 20% interval with the downstream 8 to 20% group. Rows 3, 4 and 5 are now one segment (Seg # 3). • The next situation is a single 8 to 20% interval with 4 to 8% category intervals on each side. Following the criteria: 1) there are no adjacent categories; 2) no next highest categories; 3) there are similar next lowest categories upstream and downstream; 4) the downstream group has the most number of contour intervals. STOP. Lump the 8 to 20% interval with the downstream 4 to 8% group. • The next situation is a single 4 to 8% interval. Following the criteria: 1) there is now an adjacent 4 to 8% category on the downstream side. STOP. Lump the single 4 to 8% interval with the previous two rows to make a four interval segment with 4 to 8% gradient.

2.4 Layer 3: Channel Confinement Segment Breaks

Channel confinement is the third factor used in the stream segment identification process. Channel confinement is defined as the ratio of the width of the floodplain <u>to</u> the channel's bankfull width. Confinement values provide information about the ability of the channel to migrate within the floodplain under the *present* hydrologic regime (Dunne and Leopold, 1978).

Step 1: Identify and mark segment breaks based on channel confinement (under present channel conditions) on the "CONFINEMENT" map photocopy.

Use the criteria in Table 5 to identify and mark confinement breaks in the following order: a) all confined sections; b) all unconfined sections; and c) all moderately confined sections (the area remaining after doing "a" and "b").

Important valley features for determining channel confinement are: channel; floodplain; terrace; valley flat; and hillslope (Figure 22).

Channel confinement is the most difficult parameter to determine from maps or aerial photographs. Identifying terraces from floodplains within the valley flat is especially hard because indicators are often obscured by vegetation. The guiding principle for determining confinement categories is to: a) assess all available indicators; b) determine which indicators have the greatest support; and c) use the 50% confidence rule - - "greater than 50% confidence in any category equals that category and less than 50% confidence for any category is defaulted to Moderately Confined."

Remember, the objective of the office stream segment identification is to identify the most likely, least likely and suspected areas suitable for initial monitoring plan development and selection for field verification.

Table 5. Channel confinement categories, codes and descriptions.

Category	Code	Criteria
Unconfined	U	floodplain width ≥ 4 channel widths
Moderately Confined	M	floodplain width ≥ 2 and < 4 channel widths
Confined	C	floodplain width < 2 channel widths

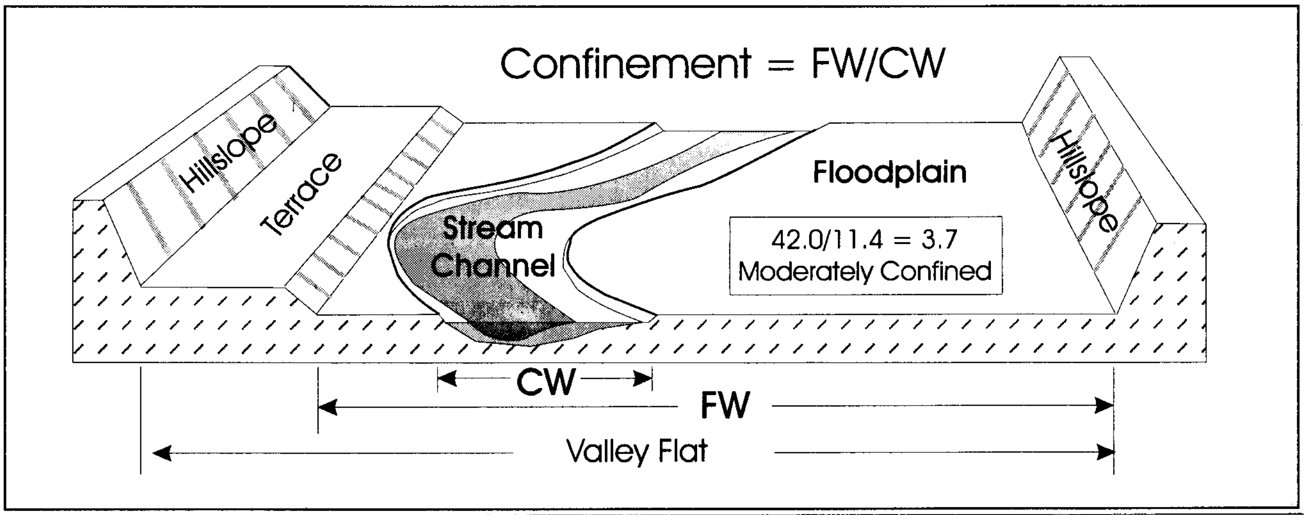

Figure 22. Channel confinement landscape examples representing unconfined, moderately confined and confined channel situations.

When stuck, work from the areas where the indicators are strong to the areas where indicators are vague. One technique is to put a color-coded dot in the center of a confident confinement category and work upstream and downstream until no longer confident. Stream sections that are not clearly confined or unconfined should be called moderately confined. Use the default method where the boundaries between two confinement categories cannot be closely identified. Find the points where indicators no longer help and mark the point halfway between as your boundary.

The most commonly used indicators of channel confinement are: floodplain/valley width; channel gradient; topographic and human controls. Always document the reasons for making confinement break calls. Code letters in brackets can be used to simplify note taking on map photocopies and L/S worksheets.

Floodplain/valley width [FVW]: It is relatively easy to pick out confined headwater and wide unconfined stream sections. The greatest difficulty is determining the point where a confinement category ends and the other, or a moderately confined section, begins. Relative floodplain/valley width can be visualized along the stream channel using a cross section technique. Similar to the gradient method, mark where each contour line crosses the stream and extend the line at an approximate 90 degree angle to the stream valley length to the next contour line or obvious confinement structure (roads/dikes) on each side. This may not work at every line crossing, especially near the tributary junctions. Measure the line distances in the obvious confined and unconfined areas and use them as guidelines for determining the locations of confinement breaks.

Channel gradient [CG]: Floodplains are typically constructed in depositional areas of a watershed. Sediment deposition generally occurs in low gradient [LG] channels with water surface slope less than 4%, so the chances of finding a significant length of unconfined channel in gradients greater than 4% are low. One exception noted is where large debris flows or LWD jams create sediment traps that temporarily (tens of hundreds of years) create significant localized floodplains (Montgomery and Buffington, 1993). It is relatively safe to assume that high gradient [HG] channels with water surface slope greater than 8% are confined.

Topographic controls [TC]: Topographic contour lines provide valuable information on landforms adjacent to the channel. Two or more parallel contour [PC] lines indicate a confined or moderately confined "V-shaped" valley. Ridges [RG] and valley walls [WL] confine channels on one or more sides and must be evaluated to see if they are the cause of forced sinuosity [FS]. Unforced sinuosity [US] (not caused by topographic controls) and braiding [BD] indicate that the channel has the ability to meander across an 'unconfined' floodplain. Conversely, straight channel lines indicate more confinement potential. Lines that flare [LF] away from the channel tend to indicate less confinement, as opposed to paralleling the stream channel. Landform topographic colors that show grass/shrub vegetation [VG] along streams may indicate less confinement, as can aerial photos showing a change from conifers to deciduous vegetation.

Human controls [HC]: Often, humans create modifications that contain or modify the channel to prevent channel waters from commonly flooding adjacent land or to utilize the terrace portions of the valley flat for construction. In these situations, look for indications of confinement by diking [DK] or channelization [CH] (straight channel in a wide valley flat), and houses [HS] /roads [RD] that are located along the channel. Structures that are designed to prevent the channel from migrating, such as riprap and other bank hardening [BH] often coincide with flood prevention and the likelihood of confinement. Culverts [CV] and many forest road bridges [BR] cause local channel confinement and must be assessed as segment breaks related to length, permanence, and significance of impact to upstream/downstream input processes.

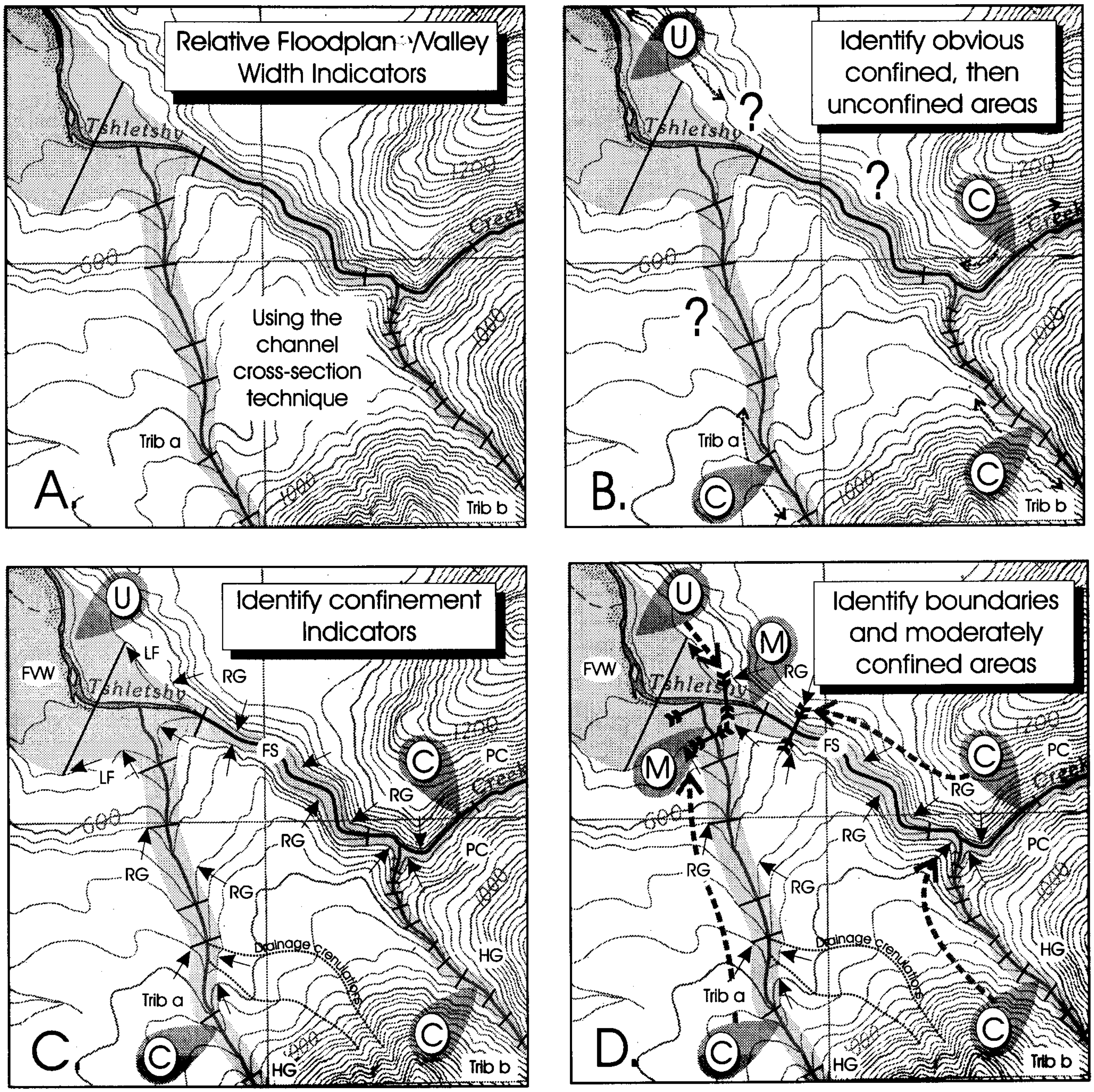

Figure 23. Detail of Tshletshy Creek provides progressive steps taken to determine confinement categories.

EXAMPLE 2.4A

The process involved in Step 1 is illustrated using a section of Tshletshy Creek and two of its tributaries (Figure 23). • First, the relative valley width is identified using the channel cross-section technique and widths interpreted between contour line intersections (Figure 23-A). • Second, confined and then unconfined areas are identified in high confidence areas (Figure 23-B). • Third, confinement indicators are identified and directions of ridges and contour line flares determined (Figure 23-C). On "Trib a", two of the contour line intersections were not suitable for the cross-section technique and other indicators were used to establish that confinement potential remained uniform. • Last, the boundaries of the confined and unconfined areas were identified and the area remaining was labeled as moderately confined.

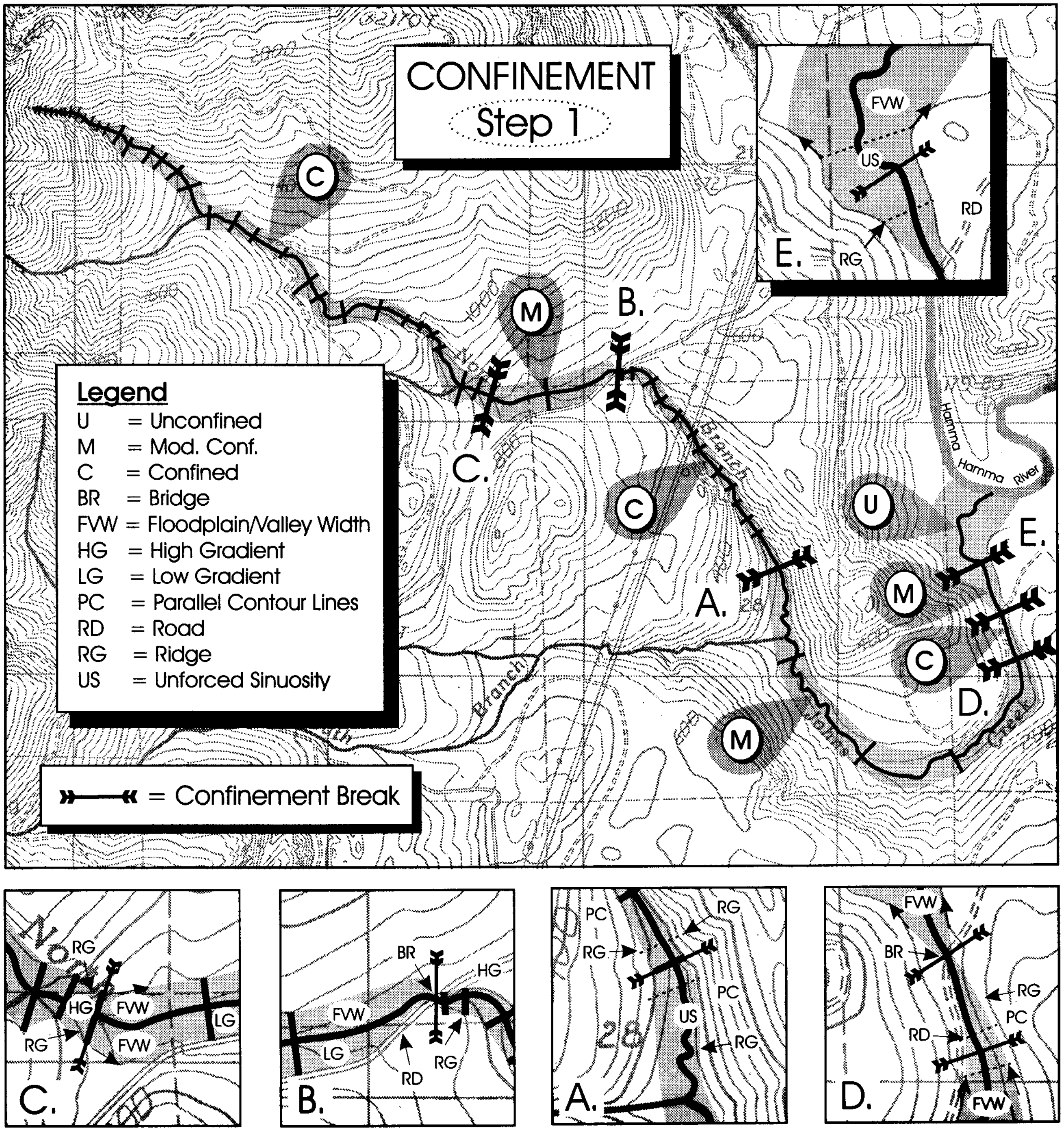

Figure 24. Detail of John Creek showing confinement categories and boundaries.

EXAMPLE 2.4B

On John Creek, the first confined stream section is located approximately between the 160 ft. and 640 ft. elevation contour lines (Figure 24). Confinement indicators are: a "narrow" valley width (relative to other map confinement cross-sections), high gradient and multiple parallel contour lines on each side. The lower boundary is marked where there is evidence of unforced sinuosity starting (Figure 24-A). The upper boundary is marked where the road crosses the stream (Figure 24-B). Although the road along the stream increases the likelihood of confinement, evidence of a widening valley (400 ft.) and spacing of

EXAMPLE 2.4B (cont.)
adjacent parallel contour lines produces low confidence.
• The second confined stream section is located at the headwaters above the 1200 ft. elevation line. Indicators are similar to the confined section noted above. Working downstream, valley width stays fairly constant to the 840 ft. elevation and high gradient around 8% until the 720 ft. elevation (Figure 24-C). Weighing the high gradient more than the changing valley width indicators, the lower boundary of the confined section is marked at the 720 ft. contour line stream intersection.
• The road along the lower portion of the stream is an indicator of potential confinement (Figure 24-D). Only the lowest portion seems to fall within and reduce the relative valley width. In addition, multiple parallel contour lines have similar intervals indicating a constant slope. These indicators provide sufficient confidence that there is a confined section at this portion of the stream.
• The most likely unconfined stream section would be at the mouth. Valley width increases on the left bank and then unforced sinuosity is evident several hundred feet below the bridge (Figure 24-E). Confidence in unconfined indicators is highest where the sinuosity starts, so the upper boundary is placed there. The remaining unidentified three stream sections are marked as moderately confined.

Step 2: Transfer Layer 3 segment break information to the "Channel Confinement Break Lump/ Split Worksheet".

Consecutively list all the confinement segments beginning at the mouth and working upstream (Figure 25). "Length" column information is used only for resolving close lumping and splitting questions. Use the "Notes" column to record segment information including supplemental sources used.

Step 3: Lump and split channel confinement segment breaks.

Splitting: Confinement-based segments can be split out (stand alone) in situations where their breaks are greater than or equal to 400 feet or 100 meters from each other. EXCEPTIONS: a) the mouth of a stream can have a minimum length of 200 feet or 100 meters regardless of confinement category; and b) streams with bankfull widths larger than 65 feet or 20 meters can use longer minimum distances.

Lumping: Confinement-based segment breaks that do not meet the splitting criteria must be lumped to adjacent breaks. This process uses a progressive set of lumping criteria that is applied sequentially until it meets the requirements of that stage. Start by:

1) Lumping all non-split MODERATELY CONFINED sections with the adjacent *longest/split* confinement category; next

2) Lump all non-split UNCONFINED sections with: a) an adjacent *Moderately Confined* segment; if not then, b) an adjacent *Confined* segment; next

3) Lump all non-split CONFINED sections with: a) an adjacent *Moderately Confined* segment; if not then, b) an adjacent *Unconfined* segment.

Seg #	Conf Cat	Length	Lump/ Split
1	U		S
2	M		S
3	C	< 800 ft	S
4	M		S
5	C		S
6	M		S
7	C		S

Figure 25. Detail of John Creek confinement information transferred to the "Channel Confinement Break Lump/Split Worksheet".

2.5 Finalizing Stream Segment Identification

There should now be three map photocopies marked with candidate segment breaks based on tributary junctions and non-fluvial features, channel gradient, and channel confinement. The following procedure combines all the layers to finalize identification of stream segments suitable for field verification and study design development of monitoring projects.

Step 1: Transfer the "GRADIENT" and "CONFINE MENT" map segment break marks to the "TRIB/FINAL" map photocopy.

Use different segment break marks or colors for each category type (Figure 26).

Step 2: Transfer the stream order or non-fluvial feature name, gradient and confinement categories, and supplemental segment information to the "Final Stream Segment Lump/ Split Worksheet".

Consecutively list all the segment categories beginning at the mouth and working upstream (Figure 27). Identify stream order or the non-fluvial feature, gradient category, confinement category and any related notes such as information on segment descriptions, access points, and field verification questions. "Length" column information is used only for resolving close lumping and splitting questions.

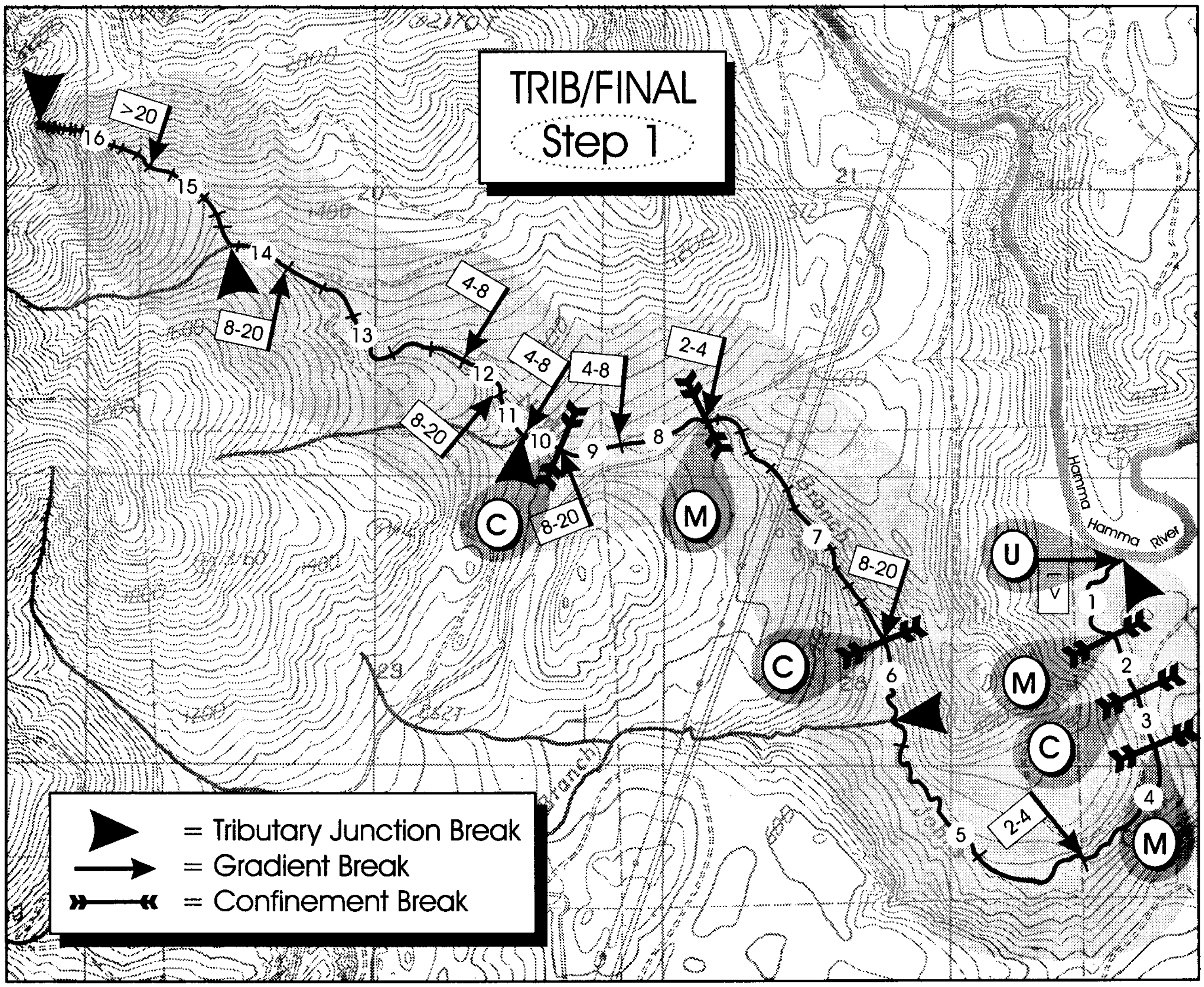

Figure 26. Detail of John Creek showing segment breaks based on tributary junctions, channel gradient, and channel confinement.

Seg #	Stream Order - NF	Grad Cat	Conf Cat	Length	Lump/ Split
1	3	< 1	U	1300 ft 400 m	S
2	3	< 1	M	700 ft 200 m	S
3	3	< 1	C	800 ft 230 m	S
4	3	< 1	M	1600 ft 500 m	S
5	3	2-4	M	3500 ft 1100 m	S
6	2	2-4	M	1000 ft 300 m	S
7	2	8-20	C	3400 ft 1050 m	S
8	2	2-4	M	1000 ft 300 m	S
9	2	4-8	M	700 ft 200 m	S
10	2	8-20	C	500 ft 150 m	S
11	2	4-8	C	500 ft 175 m	S
12	2	8-20	C	600 ft 200 m	S
13	2	4-8	C	2500 ft 800 m	S
14	2	8-20	C	700 ft 200 m	S
15	1	8-20	C	1800 ft 550 m	S
16	1	> 20	C	1000 ft 300 m	S

Figure 27. Detail of John Creek information listed on the "Final Segment Break Lump/Split Worksheet".

Step 3: Split and lump final segment breaks.

Splitting: Identify breaks from the same or different layers that are greater than 400 feet or 100 meters from each other. These segments are split out (stand alone). EXCEPTIONS: a) the mouth of a stream can have a minimum length of 200 feet or 100 meters regardless of tributary junction, gradient category, or confinement category; b) original gradient-based segments comprised of two or more adjacent contour intervals; and c) streams with bankfull widths larger than 65 feet or 20 meters can use longer minimum distances.

Lumping: Identify breaks from the same or different layers that are less than 400 feet or 100 meters from each other. In each case, use the following procedure:

a) resolve all conflicts involving a tributary junction or non-fluvial feature break by lumping conflicting gradient and confinement breaks with tributary junctions or non-fluvial feature breaks; and

b) resolve all remaining confinement conflicts by lumping them with gradient breaks.

After finishing the lumping and splitting step, the office stream segment identification process is completed with the creation of a map showing the boundary locations of all stream segments and non-fluvial features. These segments are the basic starting points for identifying potential response areas within a watershed, applying the optional sub-segment identification method to meet individual needs, and for selecting individual segments for field verification. Information from this table is also useful to identify segments for conducting the Fish Habitat Assessment Module in Watershed Analysis.

Although most cooperators will focus on only a few of the delineated office segments for a particular monitoring study, it is important to keep all information gathered about the other segments in the watershed. This benefits future monitoring efforts and provides documentation of the process used to identify other segments.

EXAMPLE 2.5A
All 16 stream segments on John Creek meet splitting criteria. Length information is provided for each segment and field verification information is noted on the Final L/S worksheet.

EXAMPLE 2.5B
The distance between a tributary break and gradient/confinement break does not meet splitting criteria for a section on Kennedy Creek. In this situation, lumping criteria number 1 would apply and the segment break would fall at the tributary. This results in a slightly larger "less than 1% and unconfined" stream segment (Figure 28).

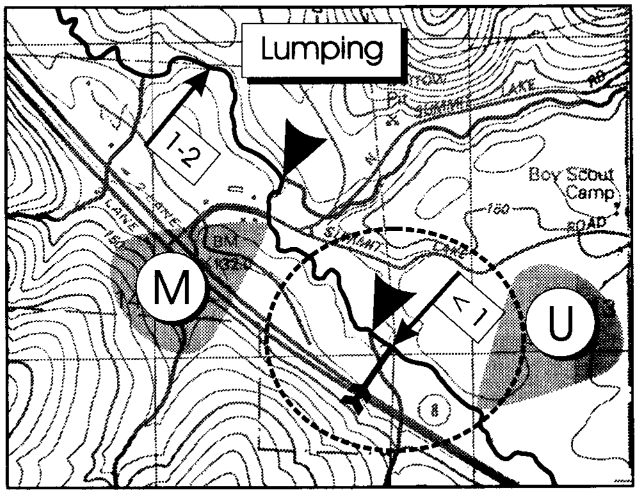

Figure 28. Detail of Kennedy Creek showing example of conflicting segment boundary layers and using final criteria to lump gradient and confinement breaks into the tributary junction.

2.6 Optional Sub-Segment Identification

The Office Stream Segment Identification method described above is designed to provide consistency between segments delineated by various cooperators. However, many cooperators have indicated a need for flexibility in splitting out smaller reaches in response to changes in land use, local stream anomalies, or to address the specific needs of a study. These situations occur where factors such as fish use, sediment load, water supply, channel morphology, and land use can cause significant variation within a segment. In these cases, each segment can be potentially split into smaller sub-segments using a system of single or double letter codes (from a to zz) after the core segment number.

Possible uses for sub-segments:

- Attachment or duplication of historic or contemporary survey data
- Junctions of minor or unmarked tributaries
- Separation of large falls, cascades, or other anomalous gradient features from study design
- Long side channels or those using bankfull width criteria different from the main channel
- Unlisted sloughs and delta distributaries
- Areas of land use change or input source
- Historic spawning areas
- Suspected or known fish passage barriers
- Access restrictions
- Culverts
- Changes in flow due to withdrawals, etc.
- Special projects (e.g., restoration effectiveness, Watershed Analysis 300 meter survey reaches)

Sub-segments *must* fit within a defined TFW-based segment. Justification for sub-segmenting is at the discretion and responsibility of the project leader.

EXAMPLE 2.6A
The first 200 meters of segment 1 on John Creek are affected by cattle use. If the cooperator is interested in conducting the Salmonid Spawning Gravel Composition Survey on this segment, justification can be made for sub-segmenting based on the need to separate forestry impacts from agricultural ones. The section with cows would be called segment "1a" and the section above would be called segment "1b".

EXAMPLE 2.6B
A cooperator wants to duplicate an old monitoring study that used a different segment classification system. The boundaries of the old survey do not correspond to the boundaries identified using the Stream Segment Identification method. Figure 29 provides a simple illustration of this problem where the lower boundary of the old segment falls in Segment 3 and the upper boundary falls in Segment 4. Segment 3 is divided into Sub-segments 3a and 3b and Segment 4 is divided likewise. The cooperator now has the choice of monitoring all sub-segments or only Sub-segments 3b and 4a to duplicate the old survey. This process allows the data to be separated and analyze based on individual TFW segment characteristics.

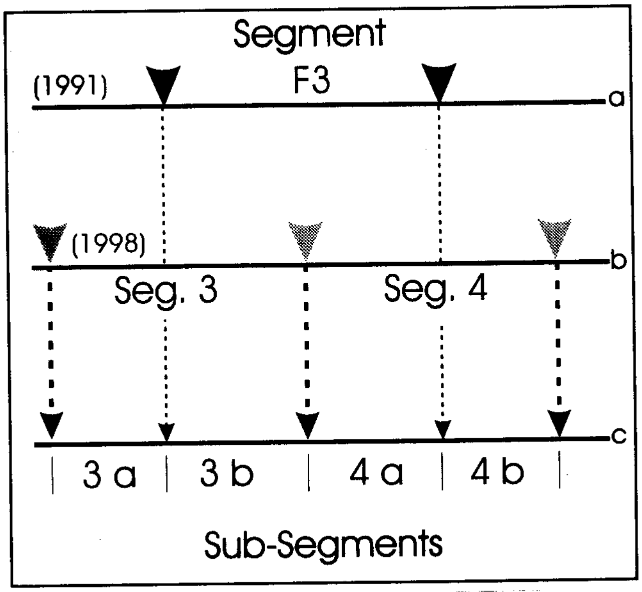

Figure 29. Example of a sub-segmenting situation for comparing historic survey data to new monitoring data.

EXAMPLE 2.6C
A project manager wants to assess the channel impacts 100 meters below and above a culvert that is within a longer segment. Five sub-segments are identified for this purpose (Figure 30). Sub-segment 14b identifies the 100 meter stream reach below and sub-segment 14d identifies the 100 meter stream reach above the culvert. Sub-segment 14c identifies the reach of stream that flows through the culvert and provides a place for attaching specific culvert assessment data. Sub-segments 14a and 14e can be surveyed as control or reference reaches. As this example demonstrates, the sub-segmenting system allows multiple possibilities for analysis of information.

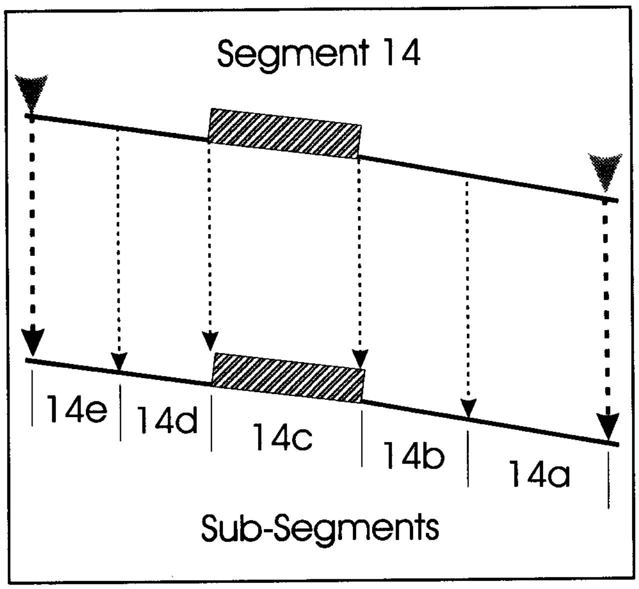

Figure 30. Example of a sub-segmenting situation with a culvert survey.

3. Field Segment Verification

The office procedure provided the first cut for determining the likelihood of finding a segment with suitable monitoring characteristics. The field verification section provides the final cut for determining whether the selected segment is useful for a particular monitoring design. To accomplish this, it is necessary to confirm the location of stream segments boundaries, verify that their gradient and confinement categories are correct, and determine whether the distance between the boundaries meets the minimum length required for effective analysis. This procedure involves walking the entire selected segment's length, determining tributary junction/non-fluvial feature locations, and either estimating or measuring actual channel and floodplain dimensions. Worksheet notes taken during the office procedure are helpful for identifying the expected locations of segment break areas and anomalies.

For effective analysis of stream segments used in monitoring studies, the TFW Monitoring Program recommends a minimum segment length based on 20 channel widths with the smallest possible segment being 100 meters (300 feet) (MacDonald et al., 1991; Montgomery and Buffington, 1993). The basic principle is to define channel reach morphology by a minimum of three to four repeated associations of channel unit patterns for effective statistical analysis. The more repeated associations, the greater the confidence in accurate channel characterization and monitoring results. The 20-channel width criteria is based on a classic pool-riffle channel system with pools spaced every five to seven channel widths (Leopold et al., 1964). Table 6 provides an example of bankfull widths and their minimum segment lengths using this criteria.

The choice of whether to lump or split anomalous stream reaches shorter than 100 meters is left with the project leader, and will depend on factors such as the degree of difference and the intended use of the information. For each segment that is surveyed, please describe the methods used to determine and the extent of variation in gradient and confinement within the reach on the field notes section of Form 1.

Table 6. Minimum segment length examples based on the 20 channel width geomorphology criteria.

Meters		Feet	
Bankfull Width	**Minimum Segment Length**	**Bankfull Width**	**Minimum Segment Length**
≤ 5 m	100 m	≤ 15 ft.	300 ft.
10 m	200 m	30 ft.	600 ft.
15 m	300 m	45 ft.	900 ft.
20 m	400 m	65 ft.	1300 ft.

This section provides information, procedures, and guidelines on what and how to collect field segment verification data. The last part of this section provides steps for finalizing segment boundaries and determining the channel gradient and confinement between them. The TFW Monitoring Program is currently developing a comprehensive standard field segment verification methodology. Contact the program for information and assistance if you need help in identifying field verification methods or resolving complex segment boundary situations.

3.1 Field Preparation

This section provides a list of core and supplemental material and equipment, and procedural steps necessary to be adequately prepared for conducting field verification. The core materials are the minimum required to accomplish the field verification unless otherwise specified by method used. Many of the channel characteristic descriptors and indicators used during the office procedure will be helpful during field verification. Refer to Appendix A for material, equipment resources, and suppliers.

Core Field Materials and Equipment

- Leveling instrument
  (Autolevel; Abney Level; Pea Level)
- Support pole
  (Tripod; monopod; custom support pole)
- Sighting pole
  (Stadia rod; story pole; custom pole)
- Distance measurement instrument
  (Hip-chain; fiberglass tape, logger's tape; elec. range finder)
- TRIB/FINAL map photocopy
- Final Segment Break Lump/Split worksheet notes
- Standard Field Gear (Appendix J)

Supplemental Field Materials and Equipment

- Aerial photo in waterproof/clear case
- Logging road map
- GPS equipment
- Standard Vehicle Gear (Appendix J)

Pre-field preparation is accomplished by completing the following steps:

Step 1: Gather and organize all core and supplemental materials/equipment.

The TRIB/FINAL map and Final Segment Break Lump/Split worksheet created during the office procedure are helpful to identify the expected locations of segment break areas and anomalies. Copy them onto waterproof paper for durability and prevention of loss.

Step 2: Select and document stream access points.

Obtain directions and maps. Determine the type of vehicle required.

Step 3: Contact landowners and secure permission to cross property.

Determine if the access roads are gated and get gate keys or make necessary arrangements with landowner to open access.

Step 4: Check all measurement equipment for damage and accuracy before use.

3.2 Tributary Junction and Non-Fluvial Feature Field Verification

Tributary junction boundaries are usually the easiest to verify. A copy of the topographic map and an aerial photograph can often lead a crew person directly to the site. Segment boundaries are temporarily flagged at the upstream side (top) of tributary junctions.

Non-fluvial features are easy to identify, but their boundaries often require investigation to determine the extent of adjacent channel influences. Use the definitions found in the office procedure (pages 10-12) to help verify and temporarily flag the boundaries of lakes, wetlands and tidally-influenced stream sections. Another way to think about it is to ask where a wetland, lake or estuary biologist would define their study boundary. Lower boundaries of water supply facilities should be placed at the downstream limit of direct hydrologic/geomorphic influences such as channelization. Upper boundaries should be place at the upstream limit of similar influences such as gravel and LWD removal areas, and upstream back-water effects during storm events.

Always start below and finish above suspected tributary junction or non-fluvial feature boundary change points. Mark the location on a copy of the USGS topographic map or aerial photograph to provide documentation.

3.3 Channel Gradient Field Verification

Channel gradient is determined by dividing the difference in surface water elevation (rise) by the distance (run) between the lower and upper segment boundaries along the centerline of the bankfull channel. We recommend using the longitudinal profile measurement survey method as described in Harrelson et al.'s (1994) "Stream Channel Reference Sites: An illustrated guide to field technique" (see Appendix A for information on ordering).

Channel gradient changes are often subtle and can take place over a transitional distance. It can be helpful to think of gradient as a surrogate for stream energy. Changes in channel gradient category are often identified by observing hydrologic, geomorphic and vegetative factors that indicate changes in energy patterns such as water speed and surface turbulence, changes in sediment size, and aquatic vegetation growth. Always start below and finish above suspected channel gradient boundary change points. Temporarily flag suspected boundaries and mark their location on a copy of the USGS topographic map or aerial photograph to provide documentation.

Field verification of gradient characteristics is a good opportunity to collect optional information on the locations of dry or flowing tributary junctions, dry or flowing side channel exit and entry points, springs, suspected adjacent wetlands, and off-channel habitat. Note the bank where the feature is found.

3.4 Channel Confinement Field Verification

Channel confinement is determined at evenly spaced interval points along the longitudinal profile of a channel by measuring both the floodplain width and the bankfull channel width. Floodplain widths are taken at 90 degree angles along the valley flat centerline. Bankfull widths are measured at 90 degree angles along the bankfull channel centerline.

Channel confinement changes are often the most difficult to identify. It is important to take the time and investigate both inside and outside the channel. Review the definitions and indicators of confinement in the office "Layer 3" section as well as information on bankfull channel edge identification in the Reference Point Survey. Investigate downstream and upstream of the suspected confinement break and identify the boundaries between the bankfull channel edges, floodplain and terrace or hillslope areas with temporary flagging. View these indicators from several angles and discuss the calls with other crew members. Then use your best judgement to decide bankfull and floodplain boundaries. Always start below and finish above suspected channel confinement boundary change points. Temporarily flag suspected boundaries and mark their location on a copy of the USGS topographic map or aerial photograph to provide documentation.

Field verification of confinement characteristics is a good opportunity to collect optional information on human confinement modification and Montgomery and Buffington (1993) channel types. Human confinement modifications such as diking, channelization, and road beds that affect confinement for more than 10% of each measurement interval distance are noted with a check mark and its location described as either the left bank (LB), right bank (RB) or both banks (BB). Use the Field Notes section to describe the modification. For channel type information, use the two letter Channel Type code. Refer to Montgomery and Buffington's (1993) report for information on how to identify channel types.

3.5 Finalizing Segment Field Verification

Finalization of segment boundaries and characteristics is completed by following the four-step process outlined below.

Step 1: Gather together all segment field verification information.

Gather all field notes and error check each sheet for completeness, legibility and calculations.

Step 2: Finalize lower and upper segment boundary locations.

Use the field verification information to resolve segment boundary locations where individual channel characteristics are not clear or multiple characteristics do not coincide. In situations where boundaries are not clear, use the default system. Identify the downstream and upstream points where there is 100% confidence in a call, and the point halfway between is the default boundary. In situations where multiple characteristic boundaries do not coincide, the general rule is to make the boundary using the following priority: 1) at a tributary junction or non-fluvial feature; 2) at a gradient category change; or 3) at a confinement category change.

Step 3: Calculate channel gradient and confinement between segment boundaries.

Segment data gathered using estimation techniques is useful only for verifying categories of channel gradient and confinement. Actual mean segment gradient is calculated by dividing the elevation Rise by the distance Run between the boundaries. The result is then changed into a percentage and rounded to the nearest tenth of a percent (e.g., .037 = 3.7%). Actual mean confinement is calculated by summing the "Confinement Ratio" of each measurement interval between the boundaries and dividing by the number of intervals. Round the result to the nearest tenth (e.g., 3.24 = 3.2).

In many cases, a stream segment that appears to be uniform according to information from the map may not actually prove to be of uniform channel gradient or confinement in the field. Often, there are short sections of greater or lesser gradient/confinement interspersed within the segment. This poses the question of whether to lump or split out short, anomalous reaches identified in the field (or on the map) as separate segments, or to include them in a larger segment. Combining them with a larger segment has the advantage of reducing the number of segments and simplifying record-keeping, but results in loss of resolution of data when smaller, unique areas are blended in with those from larger areas. Splitting out smaller segments increases complexity, but documents the unique characteristics of each distinct area.

Step 4: Transfer final segment boundary information to a clean USGS topographic map or Mylar overlay.

Compare results from the field measurements with your office determined map values. Make corrections as necessary to boundary locations and segment characteristics on the working copy of your map to document and track process and results.

4. Post-Field Documentation: Finalizing Form 1 Information

Once field verification has been completed for a segment, it's descriptors and location must be thoroughly documented. The objective is to provide enough information so that a different person 10 to 20 years from now could accurately relocate the segment and re-survey its channel characteristics to determine if change has occurred. One strategy is to imagine yourself in that person's situation and think about the information required to accomplish such a task.

There are four more sections on Form 1 to be completed using the information gathered from field verification and other sources. This includes segment descriptors, lower and upper segment boundary information, segment field note summary, and providing a segment sketch map. Refer to Appendix E for an example of a completed Form 1.

4.1 Segment Descriptors

Segment #: Record the one to three digit segment number (1 - 999).

Sub-Segment Code: Record the one- or two-letter character sub-segment code (a - z; aa - zz)

Field Verification: Circle the appropriate field verification code used to identify segment boundaries and characteristics (Figure 31). Segments that have only gone through the office stream segment identification process circle the letter "**O**". Segments that have been field verified using estimation methods circle the letter "**E**". Segments that have been field verified using the actual measurement methods circle the letter "**A**". Also, mark the appropriate circle to indicate whether the segment boundaries are original or came from another source such as a Watershed Analysis (WSA), Salmon and Steelhead Habitat Inventory and Assessment (SSHIAP), or another project.

Stream Order: Record the stream order of the segment as defined during the office stream segment identification process.

Gradient Category: Record the gradient category based on USGS topographic map interpretation (office) or using field verification information. There are six possible categories: ≤ 1%; 1 - 2%; 2 - 4%; 4 - 8%; 8 - 20 %; and > 20%.

Field Gradient: Record the estimated or actual mean field verified channel gradient to the nearest tenth of a percent.

Confinement Category: Circle the appropriate letter code for confinement (U, M, or C).

Field Confinement: Record the estimated or actual mean field verified channel confinement to the nearest tenth.

Segment Descriptors

Field Verification O E A (Circle one) ● Original ○ WSA ○ SSHIAP ○ Other

Stream Order 3

Gradient Cat. 2-4 %

Field Gradient 2.7 %

Confinement Cat. C M U (Circle one)

Field Confinement 3.2

Figure 31. Detail of Form 1 "Segment Descriptors" section.

4.2 Lower & Upper Segment Boundary Information

Use the USGS 7.5 minute topographic maps, locate and record the Township, Range, Section and Quarter of Quarter Section location for both the lower and upper segment boundaries (Figure 32).

Township: Township information is displayed in bold red letters along a horizontal axis line. The number is preceded by a "T" and followed by either an "N" or "S" compass direction. All segment boundaries above the line are in one Township and those below the line are in another.

Range: Townships are divided by ranges. Range information is displayed in bold red letters along a vertical range axis line. The number is preceded by an "R" and followed by either an "E" or "W" compass direction. All segment boundaries to the right of the line are in one range and those to the left of the line are in another.

Section: Townships and ranges are further divided into Sections and these are identified by square-shaped red dashed or solid lines with a number in bold red in the center. Note: Section boundaries are not always perfectly square (use "best fit") or even present in some locations such as national parks.

Quarter of Quarter: Sections are divided into quarter-sections (NW, NE, SW or SE) and then into quarter of quarter sections. Always state the smaller quarter section before the larger quarter section. For example, "NW of SW" quarter would identify the upper left quarter of the lower left quarter section. An example of the template copy master is provided in Appendix H. Contact TFW-MP for an accurate copy master to copy onto transparency film and use for this purpose.

USGS Map Elevation: From the USGS topographic map, determine the elevation of the upper and lower boundaries of the segment being surveyed. Record the elevation and the unit of measurement (circle whether in meters or feet) of the contour line that crosses the stream closest to each respective boundary of the segment. If contour lines are not close to segment boundaries, it may be necessary to estimate.

Other Elevation: (Optional) Record elevations based on either Global Positioning Systems (GPS) or from altimeters.

W.R.I.A. River mile: From the WDFW Stream Catalog, determine and record the river mile (to the nearest tenth of a mile) of the upstream and downstream segment boundary.

Other River mile: Record any other river mile information and note whether it is from actual field measurements (measured along center of bankfull channel), USGS map, or Geographic Imaging System (GIS) methods. Circle whether the measurement is in miles or kilometers (Km).

Reference Point: If and when a Reference Point Survey is conducted, record the reference point numbers corresponding with the lower and upper segment boundaries. The beginning (lower boundary) reference point should always be "0" and run consecutively upstream.

Lower and Upper Segment Boundary Information

	Lower		Upper	
Township	2 4 N		2 4 N	
Range	0 3 W		0 3 W	
Section	2 7		2 8	
Quarter of Quarter	SW of SW		NW of SE	
		(Circle one)		(Mark one)
USGS Map Elevation	40	Meters - Feet	90	
Other Elevation		Meters - Feet		○ GPS ○ Other
W.R.I.A. River Mile	0.9		1.5	
Other River Mile		Miles - Km		○ Actual ○ USGS Map ○ GIS
Ref. Pt.	0		11	

Figure 32. Detail of Form 1 showing the "Lower and Upper Segment Boundary Information" section.

4.3 Optional Stream and Segment Descriptors

WAU #: Record the six-digit Watershed Analysis Unit (WAU) number. Refer to Appendix A for sources on where to find WAU number information.

Ecoregion: Record the two-letter code and the full ecoregion name the segment is in. Refer to Appendix A for sources on where to find copies of an ecoregion map. If the segment falls along a boundary between two ecoregions, pick the one that best represents your stream situation.

Drainage Basin Area: Record the drainage basin area either above and/or including the segment. Record the method used to obtain the area (planimeter, digitizing table, dots, etc.).

Human Confinement Modification Identified: Determine if greater than 10 percent of the total segment length confinement has been modified on one or both banks by human design (roads, diking, channelizing, etc.) and circle the appropriate letter ("Y"= yes; "N" = no).

Montgomery and Buffington (1993) Information: Space is provided on Form 1 for cooperators that are interested in using the Montgomery and Buffington (1993) channel classification system for comparison of similar segments, assessment of current segment conditions and predictions of segment responses. This includes information on Geomorphic Province, Valley Segment, and Channel Reach scales. The Watershed scale is automatically defaulted to the "Valley" level for TFW-MP purposes.

4.4 Segment Field Notes

This is the place to note segment information such as justification for sub-segmenting, landowner(s), contact numbers, local stream names, directions to access points, segment features of note, and any other information that will help someone relocate the segment or repeat the monitoring study in the future.

4.5 Map Box

Use this space to hand draw or trace a map of the stream segment to identify access points and important segment features such as access road systems, bridges, falls, impassable areas, etc. This can be as simple as a stick map or tracing important features off a topographic map.

4.6 Error Checking

Review Form 1 and all other documents compiled during Stream Segment Identification. Have a second person look them over for completeness, legibility and errors. Two of the most common sources of errors are having an improper segment number and incorrect boundary legal descriptions.

The stream's W.R.I.A. and segment number identify a unique channel location with specific lower and upper boundaries. Any time a segment's boundary information is changed, a segment number change is required to one that has not been used previously. This prevents linkages and comparisons of unlike data in the database.

The most common errors found on Form 1 are in the segment boundary descriptions for Townships, Ranges, Quarter of Quarter, Elevations and River miles. Monitoring requires repetition of the exact same segment location. Valuable time is wasted trying to validate discrepancies and tracking down correct information. Where information cannot be corrected, the data may not be useful for monitoring purposes.

The person who error checks the form puts their initials and date completed on the bottom front box on Form 1.

5. Data Management

The TFW Monitoring Program offers data management services to help cooperators quickly analyze data collected with the program's standard methods and to produce standard monitoring reports. The heart of the service is a database system housed at the Northwest Indian Fisheries Commission. This database is available to do calculations, produce reports and archive electronic versions of the data. The database is also an important archive of monitoring data that can be used for developing study designs and identifying control or reference sites. Stream segments provide the framework for referencing stream habitat information in the database. All other survey data sets are associated with, analyzed by, and relate to segment information.

5.1 Data Preparation

Before data entry can occur for each segment, some preparation must be done. In most situations, Stream Segment Identification information will be entered along with data from other monitoring surveys. The following materials are needed:

- a completed and error-checked Form 1 for each segment;
- a data entry system;
- a set of data entry system instructions; and an "Ambsys" data dictionary.

Before the data entry process can begin, an entry system must be selected. Choose the data entry system from the list below and request a free copy from the TFW Monitoring Program. The database has four entry system options for stream segment identification data. These are:

- Microsoft Excel 4.0 pre-formatted spreadsheet (Appendix F);
- Lotus 1-2-3 (version. 3) pre-formatted spreadsheet;
- Microsoft Access 2.0; and
- R:Base 4.5++.

Read the instructions for the data entry system and the Ambsys data dictionary, noting the field types and data constraints (what type data is entered into each field).

5.2 Data Processing, Products and Archiving

Open the section of the entry system pertaining to Stream Segment Identification on your computer. Following the entry system instructions, key in the data from Form 1. After you have completed keying in the data and saved the session, have another person compare the data recorded on Form 1 to the data on the screen. Once they have verified the accuracy of the entered data, save the final result to a floppy disk. When all surveys have been entered, the disk is ready to send to the TFW Monitoring Program.

Data can be sent to the TFW Monitoring Program using several different methods. A few are described here. Gather together: a) copies of the field forms; b) USGS topographic maps with the stream segment locations marked; and c) the floppy disk with the electronic version of the data. This package can be delivered in person to the Northwest Indian Fisheries Commission, or sent through the mail. The electronic versions can be sent via e-mail, and hard copies can be faxed. After the program receives the disk, the data is imported into the database by a staff person.

Reports can be generated for each survey imported into the database. A Stream Segment Description Report presents information from Form 1 as well as a list of monitoring surveys conducted, survey year, and survey leaders and their affiliations (Appendix F).

Safe and efficient archiving is also provided through Data Management Services. The data generated by individual cooperators is archived electronically in the database system. Hard copies of the field forms, topographic maps and supplemental information can also be archived at our facilities to meet quality assurance needs and to reduce the chance of loss due to personnel changes or destruction. Access to cooperator data can be limited by request.

6. References

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• Harrelson, C.C., C.L. Rawlins and J.P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61p.

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• WFPB, 1995b. Forest Practices Board Manual - Version 7/95. Prepared by the Washington Dept. of Nat. Resources Forest Practices Division. Olympia.

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• Williams, R.W., R.M. Laramie and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Vol. 1, Puget Sound Region; Volume 2, Coastal Washington. Wash. Dept. of Fisheries. Olympia.

7. Appendixes

Appendix A
Monitoring Materials, Equipment, and Information Sources

Appendix B
Form 1 Copy Master

Appendix C
Lump/Split Worksheet Copy Masters

Appendix D
Glossary of Terms

Appendix E
Completed Examples of Form 1 and Lump/Split Worksheets

Appendix F
Data Management Examples

Appendix G
Segmenting Task Checklist Copy Masters

Appendix H
Example of Gradient and Quarter of Quarter Section Template

Appendix I
Watershed Analysis Study Design Information

Appendix J
Standard Field and Vehicle Gear Checklist Copy Master

Appendix A

Monitoring Materials, Equipment, and Information Sources

Maps
Aerial Photos
Equipment
Sources for Previously Segmented Streams
Publications

Monitoring Materials, Equipment, and Information Sources

The use of trade and company names is for the benefit of the reader. Such use does not constitute an official endorsement or approval of any service or product by the TFW Monitoring Program to the exclusion of others that may be suitable.

Maps:

Purchasing:

To order USGS topographic maps direct from USGS via U.S. postal service from the Western Distribution Branch write to:

U.S. Geological Survey
Box 25286, Federal Center
Denver, CO 80225

or contact the closest Earth Science Information Center:

U.S. Geological Survey
U.S. Postal Office Building, Rm. 135
904 W. Riverside Ave.
Spokane, WA 99201

U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

or via the USGS home page at the address http://www.usgs.gov/

or by telephone: 1-800-HELP-MAPS (for local map dealer information)

or from the state, for example Washington State's Department of Natural Resources (DNR) Map and Photo Sales can be reached by telephone (360-902-1234) or visited in person on the first floor in the Natural Resource Building, 1111 Washington St., Olympia, WA.

National Wetlands Inventory (NWI) maps (7.5 minute series). These maps show wetlands which have previously been identified. NWI maps may vary considerably in their relative accuracy and reliability because varying levels of ground verification occurred across regions after aerial photos were initially interpreted. NWI maps are available from DNR Map and Photo Sales at the address listed above.

Interpretation of:

State specific Indexes may also be purchased from USGS at the above addresses. These are booklets that represent the entire state and help to identify the names of the 7.5 minute topographic maps that cover any specific area or feature (possibly excepting National Parks).

Maps for America - M. M. Thompson 1988 - published by and available from USGS
Finding Your Way With Map and Compass - Download from USGS home page

Topographic Map Symbols - USGS pamphlet - obtainable from your local USGS field office.

Aerial Photos:

Purchasing:
See also USGS Map Purchasing and DNR Photo & Map Sales

Also, you can search and order through the internet:
http://edcwww.cr.usgs.gov/webglis/glisbin/search.pl?NAPP

or contact: USGS EROS Data Center Customer Services, Sioux Falls, SD 57198
phone: 605-594-6151
fax: 605-594-6589
email: custserv@edcmail.cr.usgs.gov

Borrowing:
Check with county offices, military, or large local landowners such as timber companies or Indian tribes.

Interpretation of: Avery T. E. and G. L. Berlin. 1985. Interpretation of Aerial Photographs. Macmillan Publishing Company, New York.

Equipment:

Purchasing: Equipment can often be purchased locally. Stores listed under the yellow page headings of: Surveying Instruments & Suppliers, Hardware, Sporting Goods, Engineering Equipment & Supplies will often stock this type of equipment.

Ivor McCray's Inc.
417 Union Ave. S.E.
Olympia, WA 98501
telephone: 360-357-6707
fax: 360-357-2521

Equipment can also be purchased through catalogues:

Forestry Suppliers, Inc.
205 W. Rankin St.
P.O. Box 8397
Jackson, MS 39284-8397
telephone: 1-800-647-5368
fax: 1-800-543-4203

Terra Tech, Inc. Int'l Reforestation Suppliers
P. O. Box 5547
Eugene, OR 97405-0547
telephone: 1-800-321-1037
fax: 1-800-933-4569
website: www.terratech.net

GeoLine Positioning Systems, Inc.
1555 132nd Avenue North East
Bellevue, WA 98005-2265
telephone: 1-800-523-6408
fax: 1-206-451-4152
email: geoline@ix.netcom.com
website: www.geoline.com

Sources for Previously Segmented Streams:

Primary source: Contact the Salmon and Steelhead Inventory and Assessment Project (SSHIAP) to determine whether stream segmenting has been done for your area of interest and to find out where those segment breaks are located. -
Contact: Randy McIntosh c/o Northwest Indian Fisheries Commission
6730 Martin Way East
Olympia, WA 98516
Telephone: 360-438-1180, Fax: 360-753-8659, Email: rmcintos@nwifc.wa.gov

Secondary source: To figure out if a watershed analysis has been done for the area of interest, contact Carol Miller, Natural Resources Program Specialist, Forest Practices Division, Washington Department of Natural Resources, Olympia, WA 98504 at 360-902-1422. For a current status list of Watershed Analyses or a complete list of Watershed Administrative Unit (WAU) numbers contact Tami Grant, also at Washington Department of Natural Resources, phone number (360)902-1394.

Sources for Historical Stream (supplemental) Information:
Bureau of Reclamation
Bureau of Land Management
Local Landowners, especially Timber Companies and Indian Tribes

Publications:

MacDonald, L. H., A. W. Smart, and R. C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. U.S. Environmental Protection Agency, Region 10, Seattle, WA. 166 pp.
Contact: Seattle EPA office at 1-800-424-4372; ask for the document by title.

Omernik, J. M. and A. L. Gallant. 1986. Ecoregions of the Pacific Northwest. Map (Scale 1: 7,500,000). U.S. Environmental Protection Agency EPA/600/3-86/033. Corvalis, OR. 125 p.
Contact: Seattle EPA office at 1-800-424-4372; ask for the document by title and document number.

Harrelson, C. C., C. L. Rawlins, J. P. Potyondy. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA Forest Service. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. 61 pp.
Contact: Rocky Mountain Forest and Range Experiment Station; publications department at (970) 498 - 1719.

Appendix B

Form 1 Copy Master

(Keep original copy masters with manual)

STREAM SEGMENT IDENTIFICATION — FORM 1

W.R.I.A. # ___ ___ . ___ ___ ___ ___ | ___ | Unlisted Trib ___ ___ ___ ○ RB ○ LB | **Segment #** ______ | ______ Sub-Segment Code | **Date** ____/____/______

Stream Information

W.R.I.A. Stream Name ______________________

W.R.I.A. Basin Name ______________________

Other Stream Name (s) ______________________

USGS Topographic Map Name(s) ______________________

____

____

Project Manager ______________________

Manager Affiliation ______________________

Data Affiliation ______________________

Segment Descriptors

Field Verification **O E A** (Circle one) ○ Original ○ WSA ○ SSHIAP ○ Other

Stream Order ________

Gradient Cat. ________%

Field Gradient ________%

Confinement Cat. C M U (Circle one)

Field Confinement ________

Lower and Upper Segment Boundary Information

	Lower		*Upper*	
Township	___ ___ ___		___ ___ ___	
Range	___ ___ ___		___ ___ ___	
Section	___ ___		___ ___	
Quarter of Quarter	___ of ___	(Circle one)	___ of ___	
USGS Map Elevation	________	Meters - Feet	________	(Mark one)
Other Elevation	________	Meters - Feet	________	○ GPS ○ Other
W.R.I.A. River Mile	________		________	
Other River Mile	________	Miles - Km	________	○ Actual ○ USGS Map ○ GIS
Ref. Pt.	________		________	

Optional Stream and Segment Descriptors

WAU # ___ ___ ___ ___ ___ ___ ___ Eco Region ____ ○ Bailey (94) ○ Omernik (95)

Drainage Basin Area ________ Acres ____________ Method

Human Conf. Mod. ID Y N (Circle one) (Yes > 10% : No < 10%)

Montgomery & Buffington (1993) Information

Geomorphic Province — Geo History Type ____________

Bedrock Type ____________

Climate Type ____________

Valley Segment Type ________

Channel Reach Type ____ ○ Forced

More Info on Back

Stream Name ______________________

FORM 1

Segment Field Notes	Map Box

Appendix C

Lump/Split Worksheets Copy Masters

C-1: Trib/Non-Fluvial Break
C-2: Channel Gradient Break
C-3: Channel Confinement Break
C-4: Final Stream Segment

(Keep original copy masters with manual)

TFW-MP Segment ID

TRIB/NON-FLUVIAL Break
Lump/Split Worksheet

Stream Name: [ ]

Date ___ / ___ / ______

Map Scale [ ]

W.R.I.A. # __ __.__ __ __ __ __

CI Scale [ ]

Completed by: ______________________________

Seg #	Stream Order - NF	Length	Lump/ Split	TRIB-NF Notes

TFW-MP Segment ID

Channel GRADIENT Break Lump/Split Worksheet

Stream Name: ____________ Date ___ / ___ / ______

Map Scale ______ W.R.I.A. # __ __.__ __ __ __ __

CI Scale ______ Completed by: ________________________________

Seg #	Grad Cat	# CI	Length	Lump/ Split	Notes

TFW-MP Segment ID

Channel CONFINEMENT Break Lump/Split Worksheet

Stream Name: ____________________ Date ___ / ___ / ______

Map Scale ______ W.R.I.A. # __ __.__ __ __ __ __

CI Scale ______ Completed by: ________________________________

Seg #	Conf Cat	Length	Lump/ Split	CONFINEMENT Notes

TFW-MP Segment ID

FINAL Stream Segment Lump/Split Worksheet

Stream Name: [ ] Date ___ / ___ / ______

Map Scale [ ] W.R.I.A. # __ __.__ __ __ __ __

CI Scale [ ] Completed by: ________________________________

Seg #	Stream Order - NF	Grad Cat	Conf Cat	Length	Lump/ Split	Notes for Field Verification

Appendix D

Glossary of Terms

GLOSSARY OF TERMS

Bankfull Channel - The drainage system through which water, sediment and LWD inputs are actively transported and deposited and that are capable of containing most flows. The channel is self-formed in that the water in the channel and the debris it carries result in the channel. The water carves and maintains the conduit containing it (Dunne and Leopold, 1978). Because of the range of discharge to which most natural channels are subject, it is logical to assume that the channel shape is affected by a range of flows rather than by a single discharge (Wolman and Miller, 1960).

Bankfull Channel Edge (BFCE)- the point along the perimeter of the channel where shear stress caused by flow is just balanced by the resisting stress of the bed or banks (Leopold et al., 1964). The shape of the cross section of a river channel at any location is a function of flow, the quantity and character of the sediment in movement through the section, and the character or composition of the materials making up the bed and banks of the channel. In nature the last will usually include vegetation .

Bankfull Event - the storm system or other event that produces the water input required to bring the stream level up to or past the bankfull channel edge.

Bankfull Flow - the quantity of water measured in cubic feet or meters per minute required to bring the water level up to the bankfull channel edge.

Bankfull Stage - the height of the water surface when it intersects the bankfull channel edges. This parameter is typically measured with a staff guage. Stage corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne and Leopold, 1978).

Bankfull Width (BFW) - the distance between bankfull channel edges (BFCE) and measured at cross-sections perpendicular to the center of the channel. The location of the wetted channel, direction of flow, or the absence of water at the time of the survey does not affect this measurement.

Channel Confinement - the degree to which stream channel migration is limited in its lateral movement by terraces or hillslope. It is expressed as the ratio of the width of the floodplain to the channel's bankfull width.

Channel Gradient - Rise in water surface elevation betweem two points along the length of the bankfull channel divided by the run (distance) between them. Recorded as a percentage for each measurement sight or used to calculate the segment mean.

Channelization - The human modification of a channel which typically includes straightening and deepening to permit the water to move faster, protect against flooding and channel migration, or to drain marshy acreage for farming (Bates and Jackson, 1984).

Floodplain - (Watershed Analysis calls this the 'valley width') The relatively flat area adjoining a channel constructed by the river through lateral migration in the present climate and flooded (all or partially) at a relatively consistent recurrence interval of 1.5 years in the annual flood series; this area provides temporary storage for sediment and flood waters (Dunne and Leopold, 1978).

Fluvial - anything that is produced by the action of a stream or river (Bates and Jackson, 1984). Channels are formed and maintained through fluvial processes.

Hillslope - (also called 'valley wall') Natural boundaries that have never been occupied by the channel. Supply sediment to stream channels (Dunne and Leopold, 1978).

Island - an area of terrestrial land that is isolated from the floodplain or valley flat by the bankfull channel of a divided stream and meets the following criteria: 1) the length of the island above the bankfull channel is equal to or greater than twice the estimated bankfull channel width; and 2) it is vegetated by two or more perennial plants that are greater than 2 meters in height.

Lumping - the process of combining sections of stream to make fewer, larger, and often less homogeneous stream segments.

Mylar - a graphics media film available in sheets or rolls and useful for copying information off USGS topographic maps. Unless required, 3 mil thickness is sufficient.

Rise - Change in water surface elevation between two points along the center or approximate center of the bankfull channel.

Run - Distance between two rise measurement points along the center of the bankfull channel.

Segment Rise - Cumulative change in water surface elevation between the downstream and upstream boundaries of the segment as measured at the centers or approximate centers of the bankfull channel

Segment Run - Cumulative distance between the downstream and upstream boundaries of the segment as measured along the center of the bankfull channel.

Side Channel - A small channel divided from the primary low flow channel by an island and currently contains or would contain flowing water fed primarily by the main channel during a bankfull event. The side channel's bankfull channel edges must be definable.

Sinuosity - the extent of channel meandering typically expressed as a ratio of lengths related to: a) the bankfull channel within the floodplain; and b) the summer low flow channel within the bankfull channel. In both situations, the greater the length of the first parameter results in a greater value of sinuosity.

Splitting - the process of dividing or separating out sections of stream with similar parameters and/or other characteristics. Splitting tends to make more and smaller homogeneous stream segments.

Terrace - The inactive floodplain, or active only during severe storm events on some rivers. These are raised areas on the valley flat that were historically part of the floodplain but were abandoned when the channel cut down (e.g., due to a new relation between discharge and sediment production)(Dunne and Leopold, 1978).

Tributary - Any stream that contributes water either continuously or periodically to another stream (Bates and Jackson, 1984).

Valley flat - (also called the 'valley floor' or 'valley width') The area that at some time in the past the channel has occupied each and every position across its width. Includes terraces and floodplain (Dunne and Leopold, 1978).

Wetland - For the purpose of the Forest Practices Rules and Regulations, 'wetland' means those areas that are inundated or saturated by surface or groundwater at a frequency and duration suffiecient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, such as swamps, bogs, fens, and similar areas. This includes wetlands created, restored, or enhanced as part of a mitigation procedure. This does not include constructed wetlands or the following surface waters of the state intentionally constructed from wetland sites: Irrigation and reainage ditches, grass lined swales, canals, agricultural detention facilities, farm ponds, and landscape amenities. Explicit in this definition is the consideration of three environmental parameters: hydrology, soil, and vegetation. Observable evidence of all three parameters normally is present in wetlands (WFPB, 1995b).

Appendix E

Completed Examples of Form 1 and Lump/Split Worksheets

E-1: Form 1
E-2: Trib/Non-Fluvial Break Lump/Split Worksheet
E-3: Channel Gradient Break Lump/Split Worksheet
E-4: Channel Confinement Break Lump/Split Worksheet
E-5: Final Stream Segment Lump/Split Worksheet

(Keep original copy masters with manual)

TFW-MP Segment ID

TRIB/NON-FLUVIAL Break
Lump/Split Worksheet

Stream Name: JOHN CREEK   Date 1/21/1998

Map Scale 1:24,000   W.R.I.A. # 16.0253

CI Scale 40 FT   Completed by: Allen Pleus

Seg #	Stream Order - NF	Length	Lump/ Split	TRIB-NF Notes
1	3		S	2 > 2: From mouth to RB junction of 'South Branch' trib # 16.0254 (RM 1.5)
2	2		S	1 > 2: To junction of unlisted RB trib (RM 2.8)
3	2		S	1 > 2: To junction of headwater RB trib # 16.0258 (RM 3.6)
4	1		S	1 > 1: Headwaters - probably intermittant (RM 4.0)

Channel GRADIENT Break
Lump/Split Worksheet

Stream Name: JOHN CREEK

Date 1 / 21 / 1998

Map Scale 1:24,000

W.R.I.A. # 16.0253

CI Scale 40 FT.

Completed by: Allen Pleus

Seg #	Grad Cat	# CI	Length	Lump/ Split	Notes
1	< 1	1		S	Possible 1-2% at upper end
2	2-4	3		S	Possible 1-2% at lower end
	4-8	1	500	L	
3	8-20	10		S	W.R.I.A. designated 'Impassible Falls' somewhere below RM 2.0
	>20	1	150	L	
4	2-4	1		S	Check for higher gradients
5	4-8	1	700	S	
6	8-20	2		S	
7	4-8	1	600	S	Located just above unlisted RB trib
8	8-20	4		S	
9	4-8	2		S	
	8-20	1	200	L	Check for higher gradient in middle
	4-8	1	500	L	Check gradient above upper road
10	8-20	4		S	
	>20	1		L	
	8-20	2		S	
	>20	1		L	
	8-20	1	200	L	
11	>20	10+		S	

Channel CONFINEMENT Break
Lump/Split Worksheet

Stream Name: JOHN CREEK   Date 1/21/1998

Map Scale 1:24,000   W.R.I.A. # 16.0253

CI Scale 40 FT   Completed by: Allen Pleus

Seg #	Conf Cat	Length	Lump/ Split	CONFINEMENT Notes
1	U		S	From mouth to where LB valley wall comes in - unforced sinuosity stops
2	M		S	Section below road crossing - valley constraint - no sinuosity
3	C	< 800 ft	S	Section above road crossing - road confinement LB - uniform slope
4	M		S	Wider valley with topographic controls affecting sinuosity
5	C		S	Narrow 'V' shaped valley - high gradient
6	M		S	Above middle road - wider valley - lower gradient and slope - check road RB
7	C		S	Narrow 'V' shaped valley - high gradient - headwaters

TFW-MP Segment ID

FINAL Stream Segment Lump/Split Worksheet

Stream Name: JOHN CREEK   Date 1/21/1998

Map Scale 1:24,000   W.R.I.A. # 16.025

CI Scale 40 FT   Completed by: Allen Pleus

Seg #	Stream Order - NF	Grad Cat	Conf Cat	Length	Lump/ Split	Notes for Field Verification
1	3	< 1	U	1300 ft 400 m	S	From mouth at Hamma Hamma R. to approx. 700 ft below BR and VW narrowing on LB. Access by private road from Hwy 101. Check for HC.
2	3	< 1	M	700 ft 200 m	S	Approx. 700 ft below and up to BR. Access by road. Check for HG.
3	3	< 1	C	800 ft 230 m	S	From BR to approx. 700 ft upstream. Access by road. Check for HG.
4	3	< 1	M	1600 ft 500 m	S	From approx. 800 ft upstrm of BR to where road turns upslope on LB. Check for access points. Check for HG.
5	3	2-4	M	3500 ft 1100 m	S	Where road turns upslope on LB to SB Trib on RB. Check for access points
6	2	2-4	M	1000 ft 300 m	S	SB trib to confined HG starts. Check access points. Check for HG/transitional area.
7	2	8-20	C	3400 ft 1050 m	S	Check for fish passage barriers of cascades > 20% gradient in middle and below upper road. Access probably from upper BR.
8	2	2-4	M	1000 ft 300 m	S	BR upstrm 1000 ft. Access from road. Check for HG. Check for salmonid evidence.
9	2	4-8	M	700 ft 200 m	S	Below possible small gorge/HG area. Access from road. Check gradient.
10	2	8-20	C	500 ft 150 m	S	Small HG/confined area just below unlisted RB trib.
11	2	4-8	C	500 ft 175 m	S	Above RB trib. Access from middle road and walk upstream. Check gradient. Check for salmonid evidence.
12	2	8-20	C	600 ft 200 m	S	Small HG/confined area.
13	2	4-8	C	2500 ft 800 m	S	Section below to just above highest road. Access from BR. Check for HG > 20% in middle and dwnstrm end. Check for salmonid evidence.
14	2	8-20	C	700 ft 200 m	S	Section above highest road BR to RB trib.# 16.0258. Access from BR.
15	1	8-20	C	1800 ft 550 m	S	Headwater area above RB trib. Check for 8-12 % section.
16	1	> 20	C	1000 ft 300 m	S	Headwater area. Probably intermittant flow.

Appendix F

Data Management Examples

F-1: Excel Spreadsheet Data Entry Form
F-2: Stream Segment Description Report

Appendix G

Segmenting Task Checklist Copy Masters

G-1: Section 2 - Office Stream Segment Identification Method
G-2: Section 3 - Field Segment Verification Method
G-3: Section 4 & 5 - Post-Field Documentation: Finalizing Form 1 Information & Data Management

(Keep original copy masters with manual)

APPENDIX G

Segmenting Task Checklist

Stream Name ______________________
Date ___/___/______

Office Stream Segment Identification Method

✔*Section 2.1 Office Preparation*

- ☐ Step 1: Gather and organize all core and supplemental materials/equipment.
- ☐ Step 2: Make copies of the related stream's basin section narrative, drainage basin map, and stream number/name list.
- ☐ Step 3: Complete the header (except "Segment #") and "Stream Information" sections of Form 1.
- ☐ Step 4: Complete the header sections on all four Lump/Split (L/S) Worksheets

✔*Section 2.2 Layer 1: Tributary Junctions and Non-Fluvial Feature Segment Breaks*

- ☐ Step 1: Identify and mark stream orders on the "TRIB/FINAL" map photocopy.
- ☐ Step 2: Identify and mark segment breaks based on tributary junctions on the "TRIB/FINAL" map photocopy.
- ☐ Step 3: Identify and mark segment breaks based on non-fluvial stream features on the "TRIB/FINAL" map photocopy.
- ☐ Step 4: Transfer Layer 1 segment information to the "Tributary/Non-Fluvial Break Lump/Split Worksheet".
- ☐ Step 5: Lump and split tributary junction and non-fluvial segment breaks.

✔*Section 2.3 Layer 2: Channel Gradient Segment Breaks*

- ☐ Step 1: Identify and mark the intersection of every contour line with the stream on the "GRADIENT" map photocopy.
- ☐ Step 2: Identify and mark segment breaks based on channel gradient on the "GRADIENT" map photocopy.
- ☐ Step 3: Transfer Layer 2 segment information to the "Channel Gradient Break Lump/Split Worksheet".
- ☐ Step 4: Lump and split channel gradient segment breaks.

✔*Section 2.4 Layer 3: Channel Confinement Breaks*

- ☐ Step 1: Identify and mark segment breaks based on channel confinement (under present channel conditions) on the "CONFINEMENT" map photocopy.
- ☐ Step 2: Transfer Layer 3 segment break information to the "Channel Confinement Break Lump/Split Worksheet".
- ☐ Step 3: Lump and split channel confinement breaks.

✔*Section 2.5 Finalizing Stream Segment Identification*

- ☐ Step 1: Transfer the "GRADIENT" and "CONFINEMENT" map segment break marks to the "TRIB/FINAL" map photocopy.
- ☐ Step 2: Transfer the stream order or non-fluvial feature name, gradient category, confinement category, and supplemental segment information to the "Final Stream Segment Lump/Split Worksheet".
- ☐ Step 3: Split and lump final segment breaks.

✔*Section 2.6 Optional Sub-Segment Identification*

- ☐ Apply sub-segment strategy.

Segmenting Task Checklist

Stream Name ______________________
Date ___/___/______

Field Segment Verification

✔*Section 3.1* *Field Preparation*
- ☐ Step 1: Gather and organized all core and supplemental materials/equipment.
- ☐ Step 2: Select and document stream access points.
- ☐ Step 3: Contact landowners and secure permission to cross property.
- ☐ Step 4: Check all measurement equipment for damage and accuracy before use.

✔*Section 3.2* *Tributary Junction and Non-Fluvial Feature Field Verification*
- ☐ Verify lower tributary junction/non-fluvial featrure boundary.
- ☐ Verify uniformity of flow and fluvial characteristics between boundaries.
- ☐ Verify upper tributary junction/non-fluvial featrure boundary.

✔*Section 3.3* *Channel Gradient Field Verification*
- ☐ Verify lower channel gradient boundary.
- ☐ Verify uniformity of channel gradient category between boundaries.
- ☐ Verify upper channel gradient boundary.

✔*Section 3.4* *Channel Confinement Field Verification*
- ☐ Verify lower channel confinement boundary.
- ☐ Verify uniformity of channel confinement category between boundaries.
- ☐ Verify upper channel confinement boundary.

✔*Section 3.5* *Finalizing Segment Field Verification*
- ☐ Step 1: Gather together all segment field verification information.
- ☐ Step 2: Finalize lower and upper segment boundary locations.
- ☐ Step 3: Calculate channel gradient and confinement between segment boundaries.
- ☐ Step 4: Transfer final segment boundary information to a clean USGS topographic map or Mylar overlay.

APPENDIX G

Segmenting Task Checklist

Stream Name ______________________
Date ___/___/______

Post-Field Documentation: Finalizing Form 1 Information & Data Management

✔ *Section 4.1 Segment Descriptors*
- ☐ Segment Number
- ☐ Sub-Segment Code
- ☐ Field Verification
- ☐ Stream Order
- ☐ Gradient Category
- ☐ Field Gradient
- ☐ Confinement Category
- ☐ Field Confinement

✔ *Section 4.2 Lower and Upper Segment Boundary Information*
- ☐ Township
- ☐ Range
- ☐ Section
- ☐ Quarter of Quarter
- ☐ USGS Map Elevation
- ☐ Other Elevation
- ☐ W.R.I.A. River Mile
- ☐ Other River Mile
- ☐ Reference Point

✔ *Section 4.3 Optional Stream and Segment Descriptors*
- ☐ WAU #
- ☐ Ecoregion
- ☐ Drainage Basin Area
- ☐ Human Confinement Modification Identified
- ☐ Montgomery and Buffingtion (1993) Information

✔ *Section 4.4 Segment Field Notes*
- ☐ Finalize notes.

✔ *Section 4.5 Map Box*
- ☐ Make sketch map or paste map copy section.

✔ *Section 4.6 Error Checking*
- ☐ Form 1
- ☐ Field verification information

✔ *Section 5.1 Preparation*
- ☐ Completed and error-checked Form 1
- ☐ Data entry system
- ☐ Data entry instructions and an "Ambsys" data dictionary

✔ *Section 5.2 Data Processing, Products and Archiving*
- ☐ Key in the data from Form 1
- ☐ Error check data with original field forms
- ☐ Send completed data disk to TFW Monitoring Program
- ☐ Stream Segment Description Report sent back
- ☐ Monitoring data and segment boundary information archived

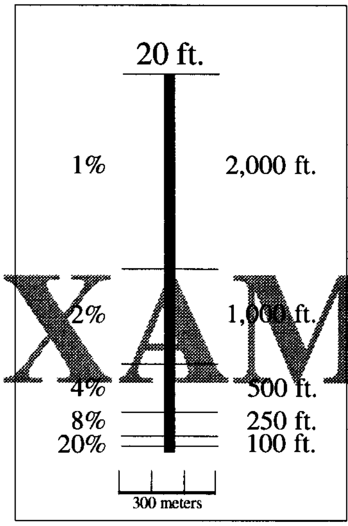
Appendix H

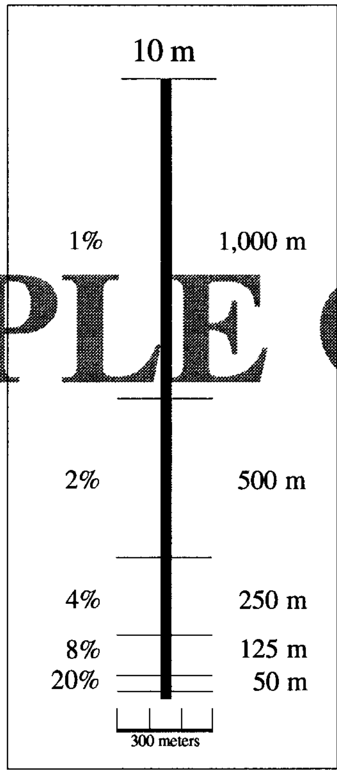
Examples of Gradient and Quarter of Quarter Section Templates

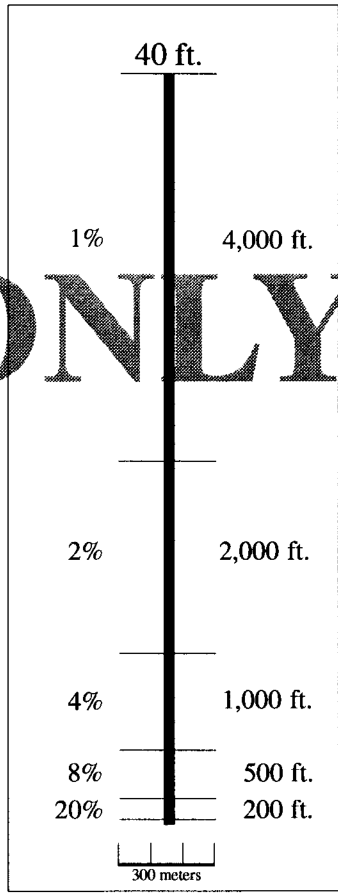
(Contact TFW-MP for a free accurate copy master)

APPENDIX H

SCALE 1:24,000





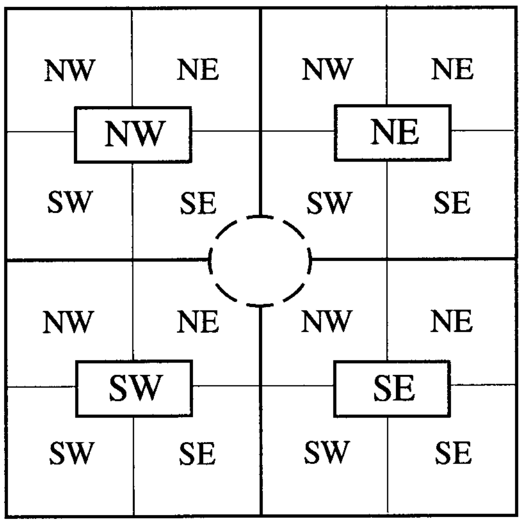


Gradient Category

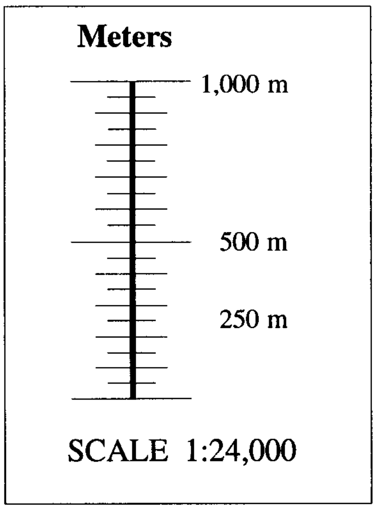
</= 1%
> 1% and </= 2%
> 2% and </= 4%
> 4% and </= 8%
> 8% and </= 20%
> 20%

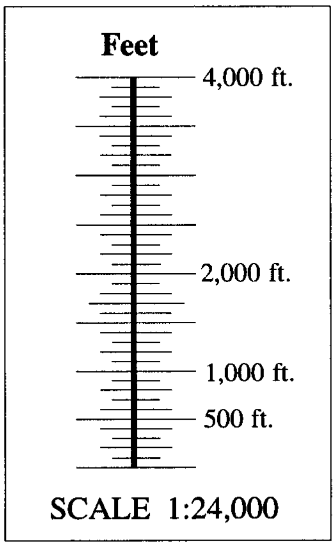
Gradient category templates for 7.5 minute USGS topo-graphical maps.

ALWAYS CHECK ACCURACY OF TEMPLATE WITH MAP SCALE!



Template for determining Section of Section locations of segment boundaries.





Copy this page onto clear acetate or overhead projector film - cut out individual pieces and laminate for durability.

Appendix I

Watershed Analysis Study Design Information

I-1: Table E-2. Channel Response Matrix
I-2: Table F-6. Potential habitat quality rating based on gradient and confinement.

Table E-2. Channel Response Matrix

SEDIMENT
FS _ Fine Sediment Deposition
CS - Coarse Sediment Deposition

DISCHARGE
SC - Scour Depth
SF - Scour Frequency
BE - Bank Erosion

WOOD
WL - Wood Loss
WA - Wood Accumulation

CATASTROPHIC EVENTS
DFS - Debris Flow Scour
DFD - Debris Flow Deposition
DB - Dam Break Flood

VW > 4CW UNCONFINED	FS BE WA	WL SF FS BE	DB DFD BE CS SF WL	DFS/DFD DB WL	DFS	....
2CW < VW < 4CW MODERATELY CONFINED	FS BE WA	CS BE SD WL FS	CS BE DB SD DFD WL SF	DFS/DFD DB SF WL	DFS	DFS
VW < 2CW CONFINED	....	CS WL	CS SD WL DFD DB	DFS/DFD DB SF WL	DFS	DFS
	< 1.0 Pool-Riffle	1.0 - 2.0 Pool-Riffle, Plane-Bed	2.0 - 4.0 Plane-Bed, Forced Pool-Riffle	4.0 - 8.0 Step-Pool	8.0 - 20.0 Cascade	> 20.0 Colluvial

VALLEY GRADIENT AND TYPICAL CHANNEL BED MORPHOLOGY

Table F-6: Potential habitat quality rating based on gradient and confinement.

Note: this table should only be used for a Level 1 assessment when limited data are available. Rating in the upper left of each box applies to anadromous salmon species. Rating in the lower right of each box applies to anadromous and resident forms of trout and char species.

Spawning and Winter Rearing

CHANNEL CONFINEMENT	GRADIENT <2%	2-4%	4-8%	8-12%	12-20%	>20%
Unconfined (VW>4CW)	GOOD / GOOD	GOOD / GOOD	FAIR / GOOD	POOR / GOOD	POOR / FAIR	POOR / POOR
Moderately Confined (2CW≤VW≤4CW)	GOOD / GOOD	GOOD / GOOD	FAIR / GOOD	POOR / GOOD	POOR / FAIR	POOR / POOR
Confined (VW<2CW)	FAIR / GOOD	FAIR / GOOD	POOR / FAIR	POOR / FAIR E-GOOD	POOR / POOR E-FAIR	POOR / POOR

E = rating for East of Cascade crest

Summer Rearing

CHANNEL CONFINEMENT	GRADIENT <2%	2-4%	4-8%	8-12%	12-20%	>20%
Unconfined (VW>4CW)	GOOD / GOOD	GOOD / GOOD	GOOD / GOOD	FAIR / GOOD	POOR / FAIR	POOR / POOR
Moderately Confined (2CW≤VW≤4CW)	GOOD / GOOD	GOOD / GOOD	GOOD / GOOD	FAIR / GOOD	POOR / FAIR	POOR / POOR
Confined (VW<2CW)	GOOD / GOOD	FAIR / GOOD	FAIR / GOOD	POOR / GOOD	POOR / FAIR	POOR / POOR

VW = Valley Width
CW = Channel Width (bankfull)

Appendix J

Standard Field and Vehicle Gear Checklist Copy Master

(Keep original copy masters with manual)

✔ STANDARD FIELD GEAR

- ☐ Field clip board/form holder
- ☐ Survey Forms (on waterproof paper)
- ☐ Copy of survey methods
- ☐ Maps- topographic and road
- ☐ Pencils & erasers
- ☐ Permanent ink marker
- ☐ Calculator
- ☐ 150 mm ruler
- ☐ Pocket field notebook

- ☐ Survey Vest
- ☐ Compass
- ☐ Safety whistle
- ☐ Spring clips (2)
- ☐ Vinyl flagging
- ☐ Pocket knife/multi-purpose tool

- ☐ Backpack or canvas tote bag
- ☐ First aid kit
- ☐ Water bottle and/or filtration system
- ☐ Food/energy bars
- ☐ Rain gear
- ☐ Leather gloves
- ☐ Safety glasses
- ☐ Bug repellant
- ☐ Sun screen
- ☐ Small flashlight or headlamp
- ☐ Matches/fire starter
- ☐ Emergency blanket
- ☐ Snake bite kit (eastern Washington)

✔ STANDARD VEHICLE GEAR

- ☐ Waterproof plastic tote box
- ☐ Backup fiberglass tape
- ☐ Comprehensive first aid kit
- ☐ Rain tarp
- ☐ Rope (100 ft.)
- ☐ Extra water
- ☐ Extra food
- ☐ Extra dry clothes
- ☐ Extra batteries

- ☐ Spare tire/jack/tire iron
- ☐ Tire sealant/inflator
- ☐ Tow strap
- ☐ Come-along winch
- ☐ Fire shovel
- ☐ Fire extinguisher
- ☐ CB radio (to monitor logging activity)
- ☐ Cell phone/VHF radio
- ☐ Brush cutter
- ☐ Ax/bow saw/chain saw
- ☐ Tire chains

✔ For remote work, extra survival & safety gear is recommended.

This gear list is provided as a guideline for outfitting field crews and is not intended to cover all situations. Local conditions may require additional or different gear.

Stream Segment Description Report

Stream Name: Unnamed Tributary

Basin Name:

WRIA: 24.0147 .01R

Segment: 217 sub: 0

Segment Location

Reference Points: to

River Miles: 0.2 to 0.4

Lower Boundary: T 16 R 7W Sec 7 NW Quarter of the NW Quarter

Upper Boundary: T 16 R 7W Sec 6 SW Quarter of the SW Quarter

Lower Elevation: 220 f

Upper Elevation: 240 f

USGS Topo Map Name: Montesano

Segment Characteristics

Average elevation (m): 70.12

Segment Length (m):

Stream Gradient (from map): 2.60 %

Gradient Category: 3 (> 2% and <= 4% slope)

Channel Confinement:

Confinement Category: Unconfined (> 4 cw)

Stream Order: 1

Channel Type:

Monitoring Surveys Conducted		Survey Leader / Affiliation
LWD Level1 Survey	10/09/1996	Charles Grover NWIFC
LWD Level2 Jam Survey	10/09/1996	Charles Grover NWIFC
Sediment Survey	10/09/1996	Devin Smith NWIFC

APPENDIX F

Stream Segment Id. Excel Entry Sheet

TFW Monitoring																																
Stream Segment Survey																																
													Lower boundary									**Upper boundary**										
wria basin	wria stream	trib	segm	sub segm	channel type (pr/pb/ sp/ca/re/b r/co/be)	map grad (%)	grad cat (1-6)	confine cat (c/m/u)	actual confine	str order	topo map name	eco region	town ship	range	section	qtr	of qtr	elevation	elev units (m/f)	river mile	ref pt	town ship	range	section	qtr	of qtr	elevation	elev units (m/f)	river mile	ref pt	field notes	entry date

STREAM SEGMENT ID

STREAM SEGMENT IDENTIFICATION — FORM 1

W.R.I.A. # 16.0253 ___ Unlisted Trib ___ ○ RB ○ LB **Segment #** 5 — Sub-Segment Code **Date** 5 / 8 / 1998

Stream Information

W.R.I.A. Stream Name: JOHN CREEK
W.R.I.A. Basin Name: HOOD CANAL
Other Stream Name (s): "JOHNS" CREEK (USGS)

USGS Topographic Map Name(s): ELDON

Project Manager: ALLEN PLEUS
Manager Affiliation: NW INDIAN FISHERIES COM.
Data Affiliation: – SAME –

Segment Descriptors

Field Verification: O E A (Circle one) — O circled

● Original
○ WSA
○ SSHIAP
○ Other

Stream Order: 3

Gradient Cat.: 2-4 %

Field Gradient: ____ %

Confinement Cat.: C M U (Circle one) — M circled

Field Confinement: ____

Lower and Upper Segment Boundary Information

	Lower		Upper	
Township	24 N		24 N	
Range	03 W		03 W	
Section	27		28	
Quarter of Quarter	SW of SW	(Circle one)	NW of SE	(Mark one)
USGS Map Elevation	40	Meters - Feet	90	
Other Elevation		Meters - Feet		○ GPS ○ Other
W.R.I.A. River Mile	0.9		1.5	
Other River Mile		Miles - Km		○ Actual ○ USGS Map ○ GIS
Ref. Pt.	Ø		11	

Optional Stream and Segment Descriptors

WAU #: 160203 Eco Region: 1g ○ Bailey (94) ● Omernik (95)

Drainage Basin Area: ____ Acres ____ Method

Human Conf. Mod. ID: Y N (Circle one) (Yes > 10% : No < 10%)

Montgomery & Buffington (1993) Information

Geomorphic Province: Geo History Type ____ Bedrock Type ____ Climate Type ____

Valley Segment Type: ____

Channel Reach Type: ___ ○ Forced

More Info on Back

Stream Name JOHN CREEK

FORM 1

Segment Field Notes

FROM OLYMPIA - (1.75 HOURS)
- I-5 SOUTH
- HWY 101 NORTH (EXIT 104)

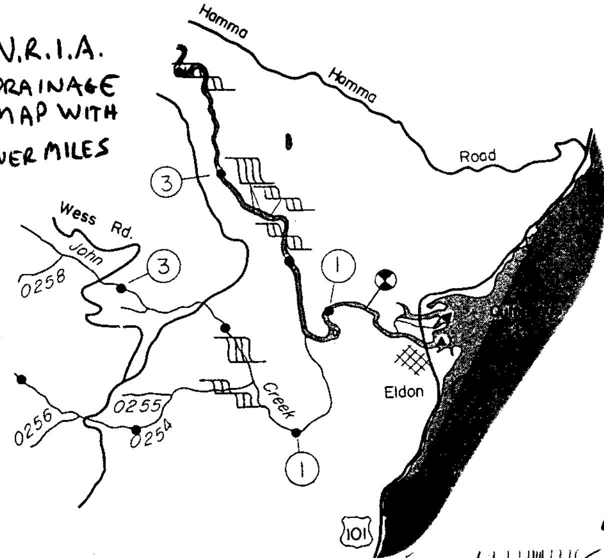
~ 25 miles NORTH OF SHELTON
BETWEEN LILLIWAUP & TRITON

LANDOWNER: JOHN SMITH (360) 555-1212
SALMON: CHUM / COHO / CUTTHROAT
LAND USE: FORESTRY

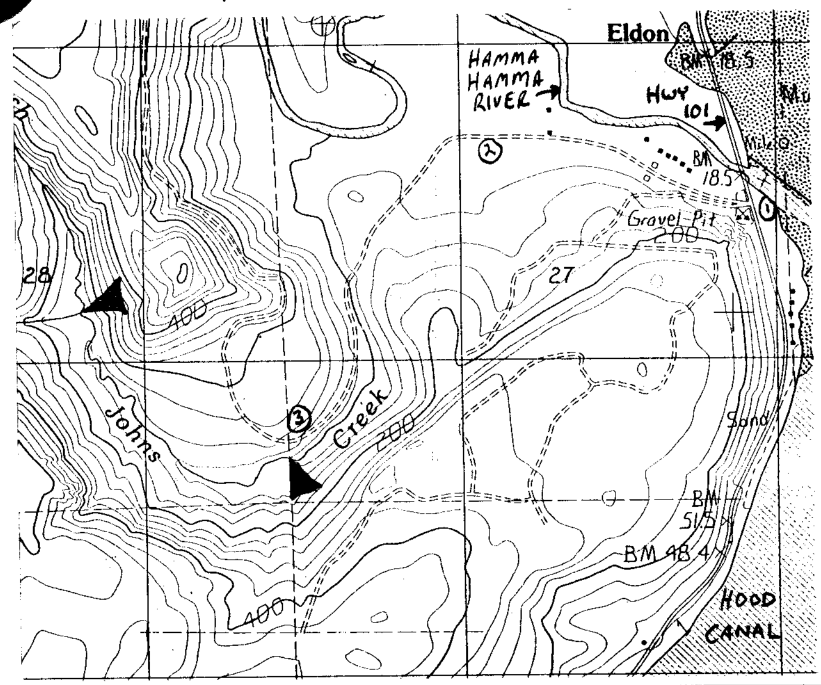
Map Box

SEGMENT 5

W.R.I.A.
DRAINAGE
MAP WITH
RIVER MILES



USGS 7.5 MIN TOPO MAP "ELDON"



1. ENTRANCE TO PRIVATE DRIVE JUST SOUTH OF HAMMA HAMMA RIVER BRIDGE
   * PERMISSION REQUIRED TO ACCESS.
2. GRAVEL LOGGING ROAD FOR ACCESS
3. ACCESS POINT WHERE ROAD TURNS AWAY FROM JOHN CREEK